Design Guidance Manual

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

Report No. SFIM-AEC-ET-OR-98046

U.S. Army Environmental Center

Prepared for

United States Army Environmental Center
Aberdeen Proving Ground, Maryland

November 1998

Prepared by

Parsons Engineering Science, Inc.
Denver, Colorado

Pacific Northwest National Laboratories
Richland, Washington

Battelle Columbus Operations
Columbus, Ohio

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DESIGN GUIDANCE MANUAL

LOW-COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM FOR EXPLOSIVES CONTAMINATED EQUIPMENT AND FACILITIES

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As part of its long-term environmental program, the Department of Defense (DoD) is required to decontaminate and remove explosives contamination from equipment and buildings at numerous DoD installations. An environmentally-safe, non-destructive method to decontaminate facilities is by the Hot Gas Decontamination (HGD) technology developed by the U.S. Army Environmental Center (USAEC). The HGD technology uses controlled heat to volatilize and thermally decompose the explosives contamination. The process was proven technically effective for decontaminating explosives contaminated equipment and facilities during several field demonstrations conducted by the USAEC. This Design Guidance Manual will assist installation personnel in determining the applicability and effectiveness of the Hot Gas technology at their site. The manual provides sufficient design information to move directly to detailed design, procurement, construction and operation of a HGD system. Technical information necessary to develop a budgetary cost estimate for implementation of the HGD process at an installation is also presented.

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EXECUTIVE SUMMARY

As part of its long-term environmental program, the Department of Defense (DoD) is required to decontaminate and remove explosives contamination from equipment and buildings at numerous DoD installations. This includes facilities and equipment used in the manufacture, packing, packaging, storage, maintenance, preservation, renovation, and demilitarization of ammunition or explosives.

Decontamination of these facilities and equipment must be undertaken in a safe, responsible and environmentally acceptable manner. The standard methods for decontamination include open burning or incineration, or surficial cleaning by solvent wiping, pressure washing, or steam cleaning. Each of these methods has drawbacks related to incomplete decontamination by surface cleaning, health and safety concerns, environmental prohibitions, and/or cost. The long-time historical decontamination method was to fill the building with combustible and flammable materials, and destroy the building and contaminants by open burning. This method is no longer acceptable at most locations due to air pollution control restrictions, proximity to adjacent buildings, and for health and safety reasons. Also, there is a desire to preserve buildings for reuse, and recycle equipment and scrap metal.

An environmentally-safe, non-destructive alternative is to decontaminate facilities using the Hot Gas Decontamination (HGD) technology developed by the U.S. Army Environmental Center (USAEC). The HGD technology uses controlled heat to volatilize and thermally decompose the explosives contamination. The process was proven technically effective for decontaminating explosives contaminated equipment and facilities during several field demonstrations conducted by the USAEC. Successful full-scale field demonstrations were performed at Cornhusker Army Ammunition Plant (Nebraska), Hawthorne Army Depot (Nevada), and the Alabama Army Ammunition Plant decontaminating explosives contaminated equipment and facilities. Also, the HGD process was proven effective in decontaminating chemical warfare-contaminated facilities and equipment in a pilot scale demonstration at Dugway Proving Ground (Utah) and a full-scale field demonstration at Rocky Mountain Arsenal (Colorado). Sampling and analysis for targeted contaminants (explosives or chemical agent) after HGD at these locations demonstrated that the process had decontaminated the areas to an analytically clean level. Decontamination efficiencies up to 99.9999% removal have been demonstrated using HGD technology.

This Design Guidance Manual will assist installation personnel in determining the applicability and effectiveness of the Hot Gas technology at their site. The manual provides sufficient design information to move directly to detailed design, procurement, construction and operation of a HGD system. Technical information necessary to develop a budgetary cost estimate for implementation of the HGD process at an installation is also presented.

Now that the technical feasibility of the technology has been established, the USAEC is concentrating on lowering the cost for HGD process implementation. The HGD technology has recently been further developed by USAEC to be economically competitive, environmentally sound, and technically superior to the alternatives. The lessons learned in

previous technology demonstrations are the basis for the current low cost thrust. Several features contribute to the technology's low cost and technical effectiveness including:

- A simple repeatable design;
- Use of locally available stock items, standard equipment, and expendables;
- Use of standard materials of construction;
- Simple control system and operation;
- Based on a one-time use and short project life;
- No R&D add-ons;
- Use of leased and rental equipment where possible; and
- Using minimum manpower and utility requirements.

Also, HGD of equipment and structures *in-situ* eliminates the expense of labor intensive dismantlement by personnel in personal protective equipment.

An existing explosives washout facility was used as a model to develop equipment sizing and cost for a typical low-cost HGD system. A preliminary cost estimate is presented here for design, procurement, construction, operation, and decommissioning of a low-cost HGD system at the model facility.

The requirement for off-gas treatment of emissions greatly influences the cost of the HGD technology. There are some site locations where off-gas treatment may not be required by local and state regulatory standards, considering the site location and distance away from populated areas and off-site receptors.

The cost for the Baseline HGD System without Off-Gas Treatment is $223,000 to decontaminate a 1300 ft^2 contaminated building (or room) containing contaminated equipment, or approximately $172 per ft^2 in 1998 dollars. The HGD system can be reused in adjacent areas for a large cost reduction due to economy of size. The cost for HGD of additional adjacent square footage at the same location is about $19 per ft^2. For a 4400 ft^2 model building selected as an example, the building can be decontaminated using multiple applications of the HGD technology for $295,000 or $67 per ft^2. Implementation of the HGD will take approximately 5 months for the initial area, and about 1 month for each additional area decontaminated.

Similarly, the cost for the HGD system with the Off-Gas Treatment option is $294,000 or $226 per ft^2 to decontaminate a 1300 ft^2 contaminated building (or room) containing contaminated equipment,. Again, the system can be reused in adjacent areas for a large cost reduction. The cost for additional adjacent square footage at the same location is $25 per ft^2. The 4400 ft^2 model building can be decontaminated using HGD technology for $393,000, or $89 per ft^2.

In situ HGD technology has been developed as an acceptable and safe alternative to historical treatment methods for decontamination of contaminated buildings, equipment, and piping. *In situ* HGD technology is a lower cost alternative to *ex situ* historical treatment methods, and reduces risks to personnel.

The HGD process has an advantage over the alternatives in that it can be implemented non-destructively so that buildings can be recovered for reuse. Also, the current trend at DoD installations is to recycle as much of this scrap metal as reasonably possible. Army policy states that pipe and scrap metal from explosives plants must be treated to 5X level of decontamination (decontaminated and free of hazards) before they can be released to commercial recyclers. Consequently, there is a need for a technology to safely, effectively, and cost efficiently decontaminate scrap metal to 5X level. Recently, the Industrial Operations Command (IOC) in IOC Pam 385-1 has qualified the Hot Gas Decontamination process as capable of achieving 5X level of decontamination. This has facilitated the HGD technology to fill this need.

The HGD process for decontaminating explosives contaminated facilities is well beyond the R&D/field demonstration phase, and is ready for widespread use at DoD facilities and commercialization in the private sector.

SECTION 1

INTRODUCTION

For many years, the U.S. Army and other branches of the armed services engaged in a wide variety of activities involving the manufacture, handling, storage, testing, and disposal of explosives and chemical warfare agents. These activities resulted in the contamination of process-related equipment, piping, sewers, and structures at various Department of Defense (DoD) installations. As a result, the DoD has numerous facilities and equipment at active installations, Formerly Used Defense Sites (FUDS), and Base Realignment and Closure (BRAC) installations which are contaminated with explosives residues and chemical warfare agents. As part of its long-term environmental program, the DoD is required to decontaminate and remove explosives contamination from equipment and buildings at many of these installations. Decontamination is required when equipment or facilities are placed in standby, transferred to another location, disposed of to other government or qualified private entities, or shutdown for maintenance, repairs, alterations, or modification. There is a particular incentive to do this at FUDS and BRAC sites where property transfer to private and public entities is the issue, and time is of the essence in many instances.

The DoD must identify, contain, and eliminate toxic and hazardous materials at facilities that are declared excess, and clean up these facilities and equipment to meet regulatory standards. This remedial action must be undertaken in a responsible and environmentally sound manner. Also, there is a current thrust within DoD to reclaim and recycle reusable materials and equipment whenever economically feasible as part of the Resource Recovery and Recycle (R3) trend.

Several types of facilities, equipment, or areas may be contaminated with explosives through the nature of their use, intended use, or exposure to explosive materials operations including:

- Explosives manufacturing plants;
- Munitions demilitarization plants;
- Munitions load, assemble and pack operations;
- Explosives machining, casting, and curing;
- Laboratory testing facilities;
- Explosives washout buildings;
- Munitions storage igloos;
- Open burning and open detonation areas; and
- Range firing and target areas.

Many types of contaminated building materials, process equipment, storage tanks, ton containers, spent shells, and debris may be found at these sites. Photographs of a typical Explosives Washout Building and contaminated equipment are presented in Figures 1-1 through 1-4.

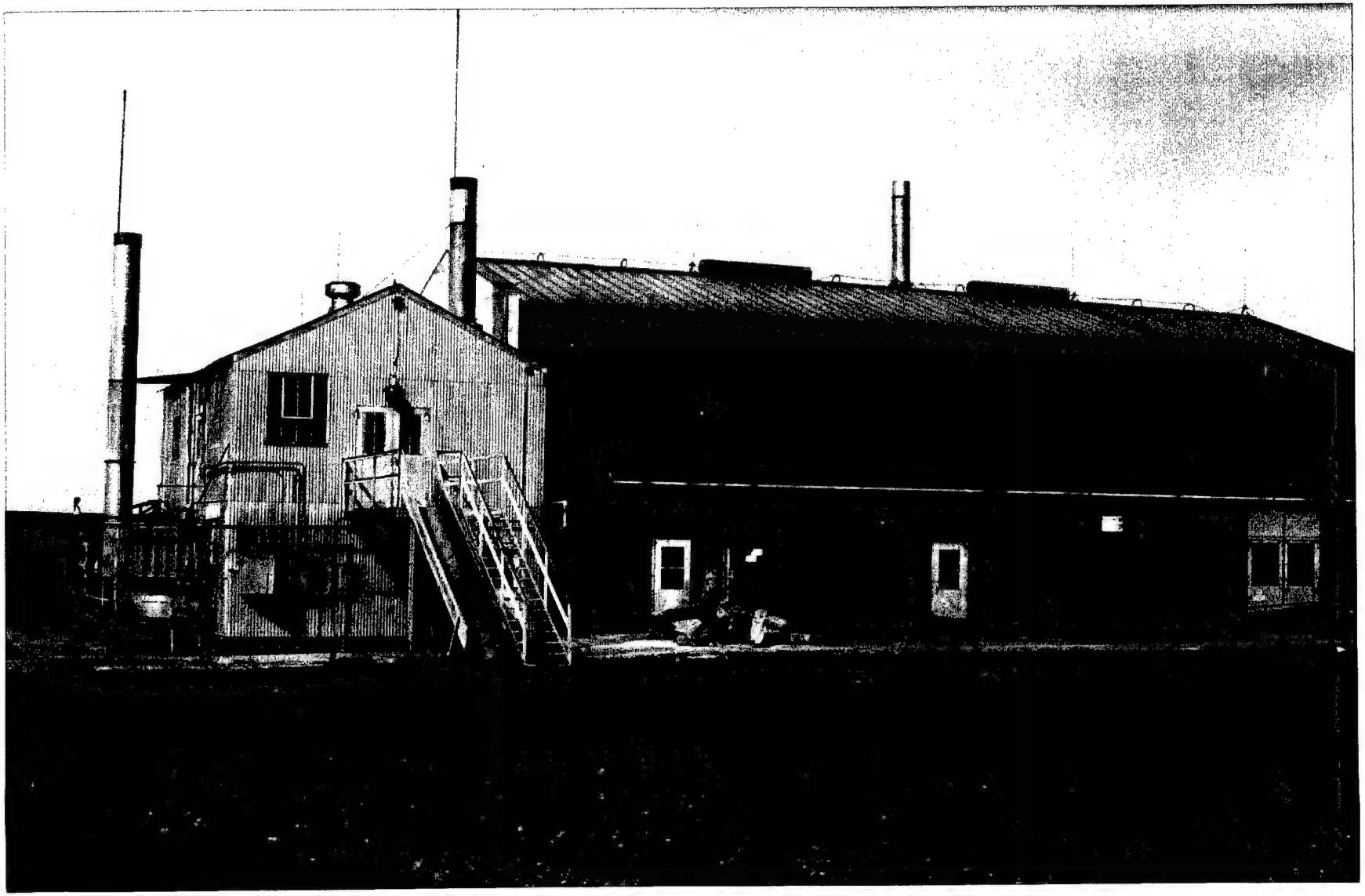


Figure 1.1
Typical Explosives Washout Building

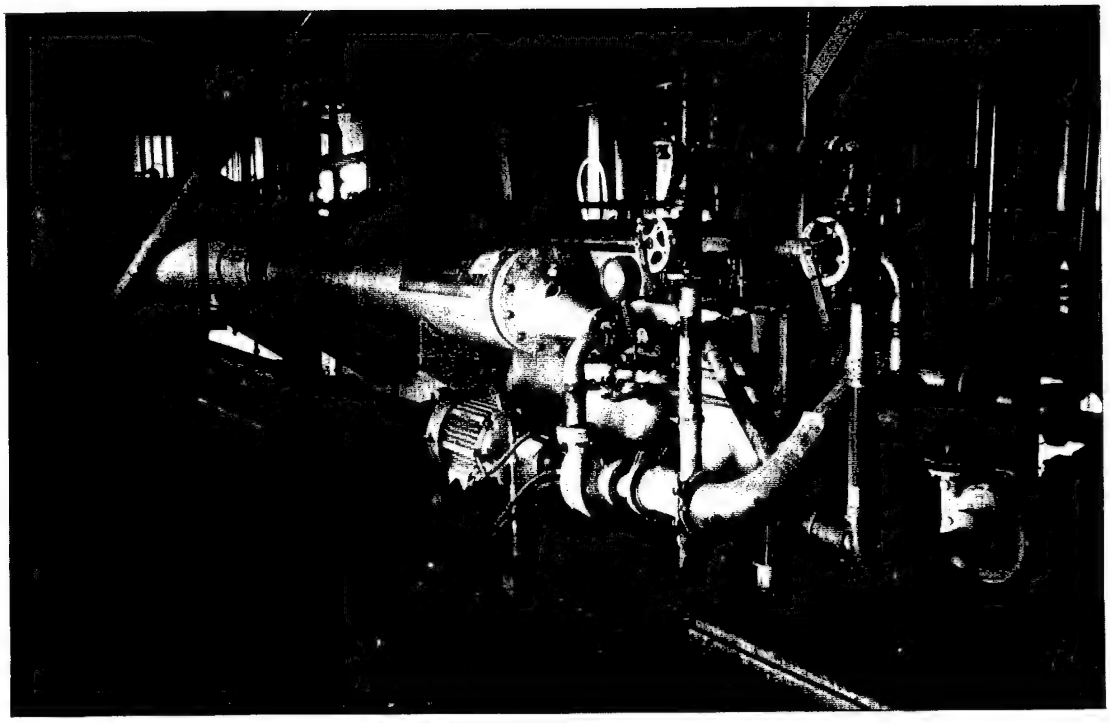


Figure 1.2
Side View Typical Process Equipment Explosives Washout Plant

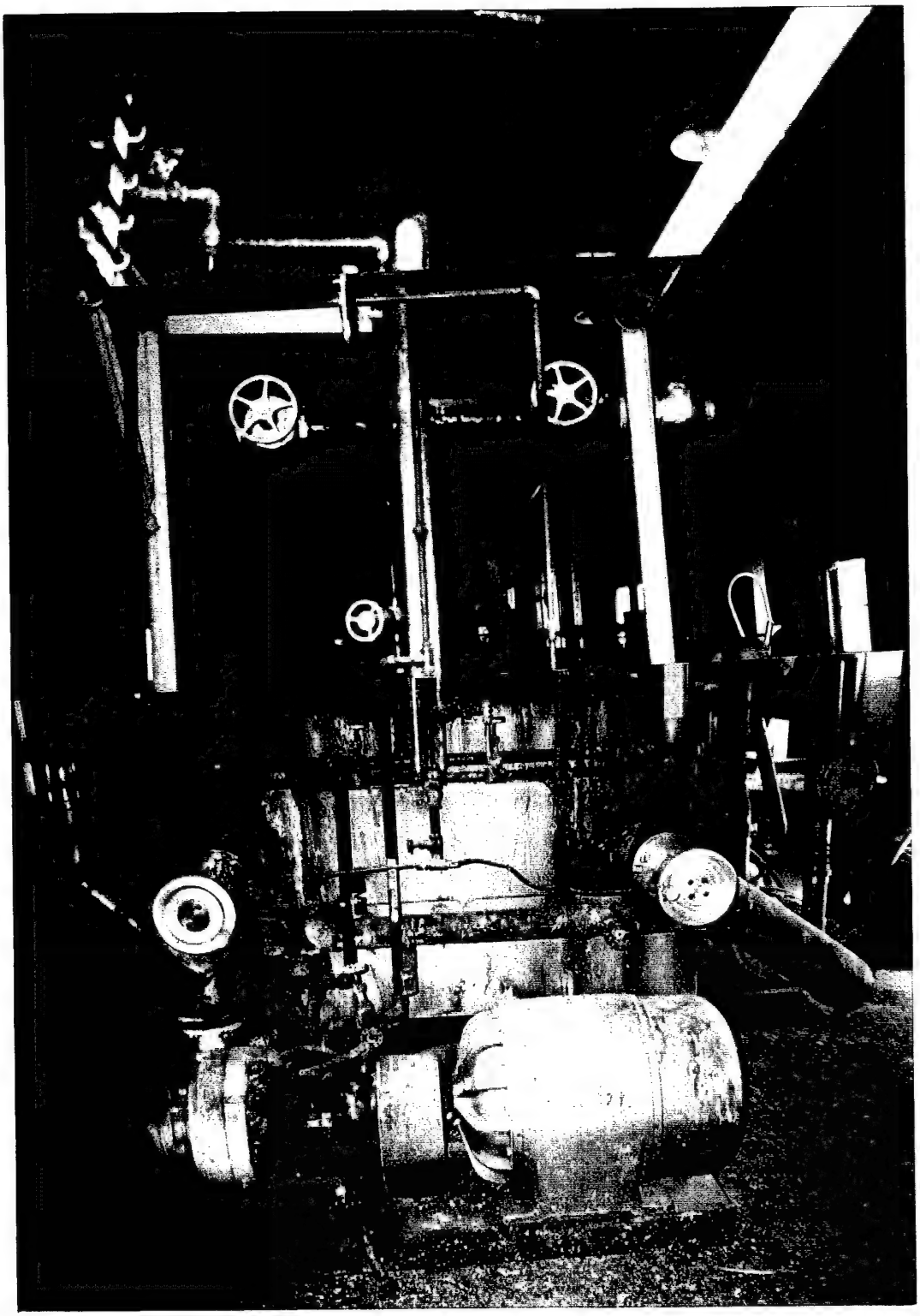


Figure 1.3
End View Typical Process Equipment Explosives Washout Plant

Figure 1.4
Washout Plant Sump-Explosives Contaminated Sludge

The standard methods for decontamination include:

- Surficial cleaning by solvent wiping, hot water pressure washing, or steam cleaning;
- Internal cleaning of pipe and vessels by hot water flushing; and/or
- Manual dismantlement followed by flaming (open burning or contained burning) or incineration.

Each of these methods has drawbacks related to relative ineffectiveness (surface cleaning), health and safety concerns, environmental prohibitions, and cost. The long-time historical decontamination method (opening burning) was conducted by filling the building with combustible and flammable materials, and destroying the contaminants as well as the building. This method is no longer acceptable at most locations due to air pollution control restrictions, and for health and safety reasons. Photographs of dismantlement and open burning in 1996 of a contaminated Explosives Washout Building (Umatilla Chemical Depot, Oregon) without containment or emissions controls are presented in Figure 1-5 through 1-7. Also, there is a desire to preserve buildings for reuse, and recycle equipment and scrap metal, which cannot be done with open burning or incineration.

An environmentally-safe, non-destructive alternative is to decontaminate facilities using the Hot Gas Decontamination (HGD) technology developed by the U.S. Army Environmental Center (USAEC), formerly known as the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). The HGD technology uses controlled heat to volatilize and thermally decompose the explosives contamination. The process was proven technically effective decontaminating explosives contaminated equipment and facilities during several field demonstrations conducted by the USAEC. Successful full-scale field demonstrations were performed at Cornhusker Army Ammunition Plant (Nebraska), Hawthorne Army Depot (Nevada), and the Alabama Army Ammunition Plant (Alabama). Also, the HGD process was proven effective in decontaminating chemical warfare-contaminated facilities in a pilot scale demonstration at Dugway Proving Ground (Utah) and a full-scale field demonstration at Rocky Mountain Arsenal (Colorado). Sampling and analysis for targeted contaminants (explosives or chemical agent) after HGD at these locations demonstrated that the process had decontaminated the areas to an analytically clean level. Decontamination efficiencies up to 99.9999% removal have been demonstrated using Hot Gas technology.

During research and development (R&D), the HGD technology gained a reputation of being expensive. R&D costs incurred in previous HGD projects included:

- Costs for a first time technology demonstration;
- Redundant safety and environmental systems;
- Testing and adjustment of operational variables during technology development;
- Additional instrumentation, controls, and monitoring required in an R&D setting; and
- Additional safety systems needed for chemical warfare agent destruction.

Now that the technical feasibility of the technology has been established, the USAEC is concentrating on lowering the cost for HGD process implementation. The HGD technology has recently been further developed by USAEC to be economically competitive, as well as environmentally sound and technically superior to the alternatives. The lessons learned in previous technology demonstrations are the basis for the current low cost thrust.

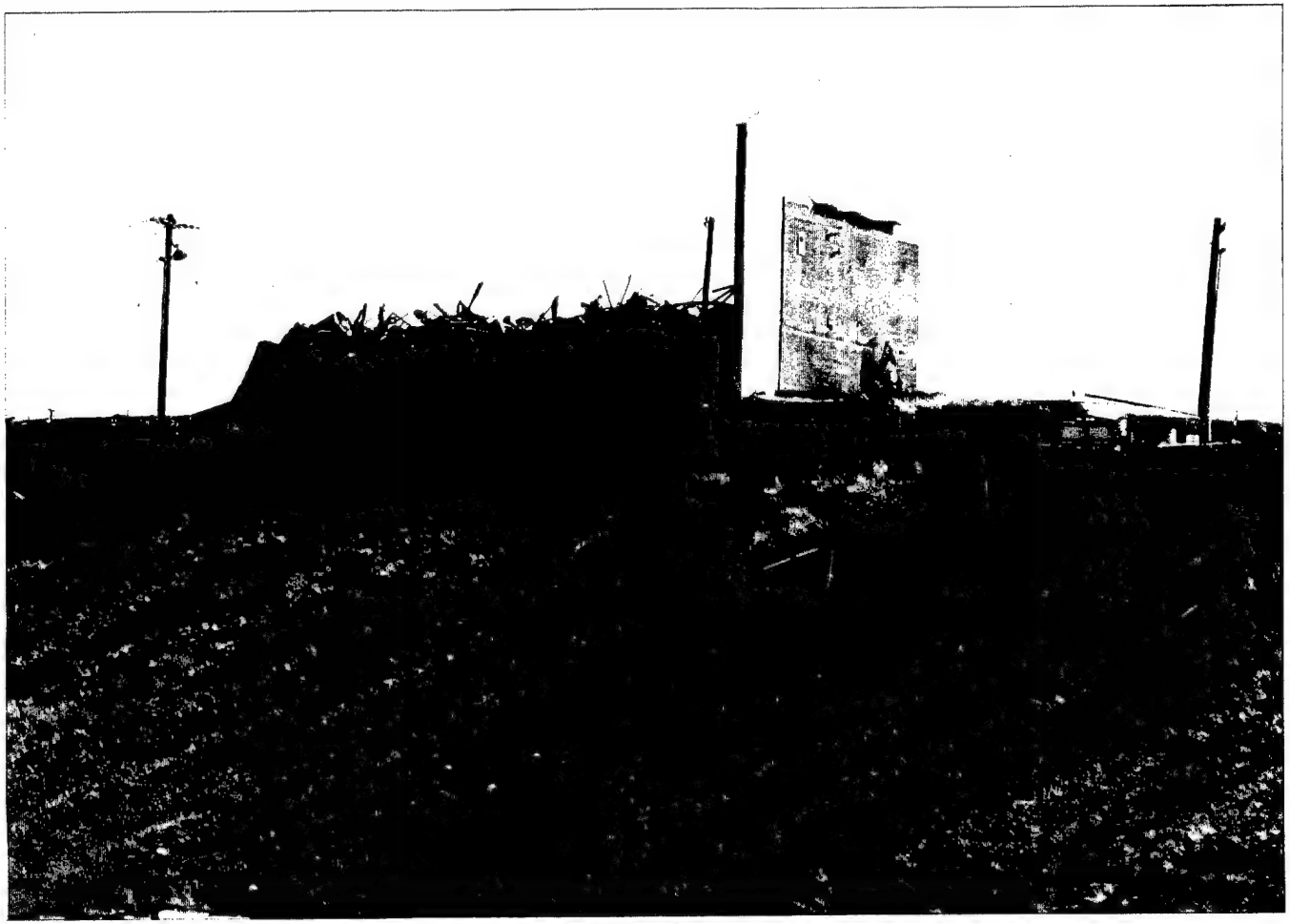


Figure 1.5
Manually Dismantled Explosives Washout Building Prior to Open Burn

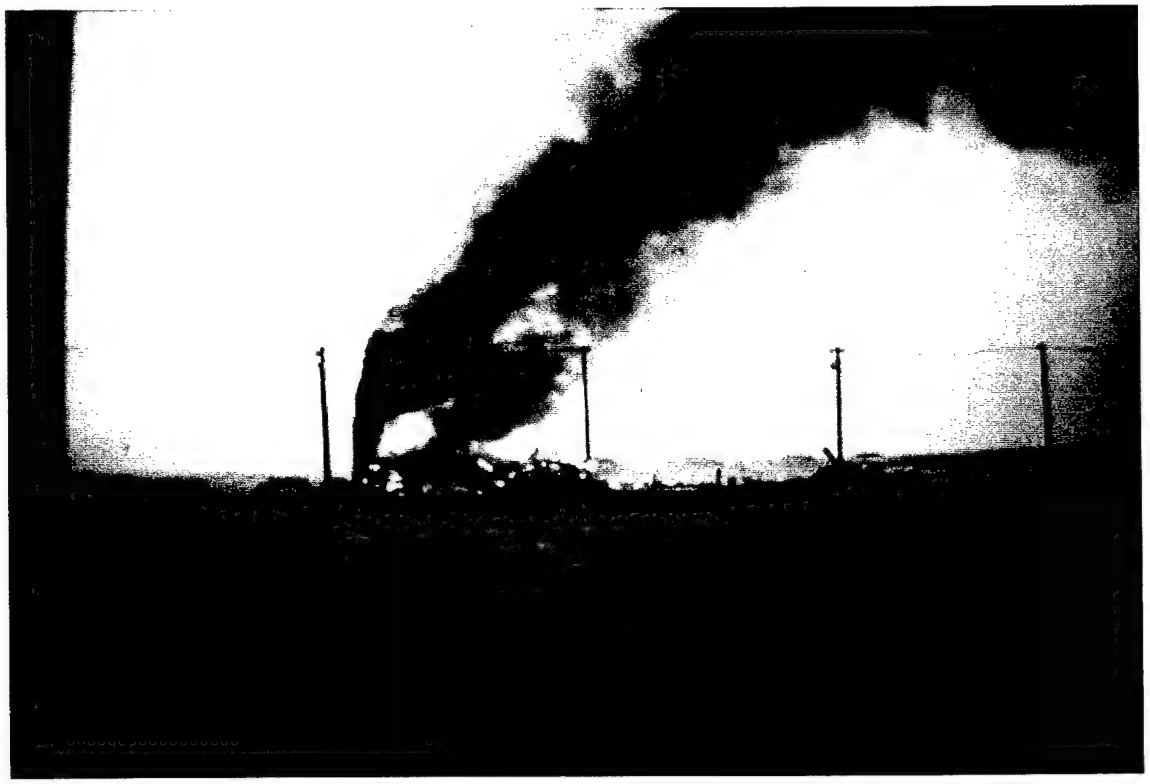


Figure 1.6
Open Burning of Dismantled Explosives Washout Building and Equipment

Figure 1.7
After Open Burning of Explosives Washout Building and Equipment

An existing explosives washout facility was used as a model to develop equipment sizing and cost for a low-cost HGD system. A preliminary cost estimate is presented for design, procurement, construction, operation, and decommissioning of a low-cost HGD system at the model facility.

Several features contribute to the technology's low cost and technical effectiveness including:

- A simple repeatable design;
- Use of locally available stock items, standard equipment, and expendables;
- Use of standard materials of construction;
- Simple control system and operation;
- Based on a one-time use and short project life;
- No R&D add-ons;
- Use of leased or rental equipment where possible; and
- Minimum manpower and utility requirements.

Also, Hot Gas decontamination of equipment and structures *in-situ* eliminates the expense of tedious manual dismantlement by personnel in personal protective equipment.

The HGD system has additional flexibility in that it can be designed with the option of having contaminated materials and equipment transported from other locations within the site to provide a cost-effective decontamination of these items.

1.1 PURPOSE AND OBJECTIVES

This design guidance manual presents a standardized low-cost design for decontaminating and decommissioning explosives contaminated facilities and equipment. The objective is to provide installation personnel with the necessary data to make informed decisions regarding the practical application of HGD technology. The basic information is provided to develop a cost estimate and design package that can be tailored to a specific installation for procurement, construction, operation (decontamination of facilities), and decommissioning.

1.2 MANUAL CONTENT AND ORGANIZATION

The following information necessary to develop an effective, low-cost, disposable HGD system is presented in this manual:

- **Process Description** for the HGD system;
- **Design Criteria** including a description of the model target facility, general functional requirements, and other considerations and limitations;
- **Standard Design Package** components which include a list of design drawings and specifications, and information for recommended equipment and components; and
- **Baseline Cost and Schedule Estimates** for the design, installation, and operation of a low-cost, disposable HGD system to decontaminate the target facility.

SECTION 2

DESCRIPTION OF THE HOT GAS DECONTAMINATION TECHNOLOGY

2.1 PROCESS DESCRIPTION

The HGD technology was developed by the U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland as an environmentally safe alternative to decontaminate equipment and facilities. The HGD process uses low temperature heat (500 600°F) to volatilize and decompose explosives residues in contaminated building materials and equipment which have been operationally contaminated. Hot burner gas directly contacts the contaminated equipment or building materials to elevate the temperature of the medium. The effectiveness of the process is both time and temperature dependent. Holding times between 1 and 6 hours have been shown to be effective at the prescribed soak temperature. Previous demonstrations of the technology have proven it effective both *in situ* (Cornhusker, Nebraska and Rocky Mountain Arsenal, Colorado) and *ex situ* by placing dismantled equipment and scrap metal in a furnace (Hawthorne, Nevada and Alabama Army Ammunition Plant, Alabama).

The Hot Gas Decontamination technology is effective in decontaminating explosives contamination for the following types of explosive materials:

- 2,4,6-Trinitrotoluene (TNT),
- Ammonium Picrate (Yellow D),
- Royal Demolition Explosives or Research Department Explosives (RDX),
- Composition A-3 (RDX and wax),
- Composition B (TNT, RDX and wax),
- Tetryl,
- Smokeless Powder (Nitrocellulose/Nitrogylcerin), and
- HBX (TNT, RDX, aluminum, lecithin, and wax).

The major advantage of the HGD process over surface decontamination methods (caustic or solvent washing, pressure washing or steam cleaning) is that it works in pores, cracks, crevices, and internal parts, as well as for surficial contamination. Up to 99.9% decontamination has been achieved by surface decontamination methods. Hot Gas decontamination however has achieved up to 99.9999% decontamination at previous demonstrations.

Volatilization is the primary decontamination mechanism, but some in-place decomposition also takes place. Because of the type and character of the constituents of the off-gas, it may be required to contain, collect, and further treat the gaseous discharge to meet environmental regulatory stipulations. At previous full-scale demonstrations of the process, a thermal oxidizer operating at 1800°F with a two-second retention time has been the standard off-gas

treatment technology. The products of combustion at this temperature are primarily carbon dioxide, water, and oxides of nitrogen (NOx).

2.2 DEPARTMENT OF DEFENSE DECONTAMINATION REQUIREMENTS

The Department of the Army Technical Bulletin, TB 700-4, Decontamination of Facilities and Equipment [1] defines the general policies, responsibilities and procedures to all U.S. Army commands and activities for decontamination of facilities and equipment exposed to potential ammunition, explosives, and explosives residue contamination. The bulletin also defines the objectives and general safety requirements associated with decontamination operations necessary to be conducted at facilities and real estate, which have been used in or exposed to explosives operations.

TB 700-4 specifically defines the degrees of decontamination to insure uniform decontamination standards as follows:

- X A single X signifies that facilities or equipment have been partially decontaminated and further decontamination is required before these items can be moved, maintained, or repaired.

- XXX Three Xs signify that facilities or equipment have been decontaminated by approved procedures and no contamination can be detected. This is typically accomplished by surface cleaning by solvent wash or other method.

- XXXXX Five Xs signify that equipment or facilities have been completely decontaminated, are free of hazards, and may be released for use by the general public or government. This has been traditionally accomplished by thermal treatment of the object to a temperature/time standard of 1000°F for a 15 minute holding time.

As a result of this Army policy, pipe and scrap metal from explosives plants must be treated to 5X before they can be released to commercial recyclers. The current trend at DoD installations is to recycle as much of this scrap metal as reasonably possible. Consequently, there is a need for a technology to safely, effectively, and economically decontaminate scrap metal to 5X level. Recently, the Industrial Operations Command (IOC) in IOC Pam 385-1 has qualified the Hot Gas Decontamination process as capable of achieving 5X level of decontamination. This has facilitated the HGD technology to fill this need.

2.3 BACKGROUND AND PRIOR DEMONSTRATION OF THE HOT GAS DECONTAMINATION TECHNOLOGY

The HGD technology is well-developed and supported by considerable research and demonstration. The USAEC began conducting bench-scale studies in the late 1970s to evaluate HGD technology for treatment of equipment, piping, metallic debris, and building materials contaminated with both explosive materials and chemical warfare agents. Successful pilot studies were followed by demonstration testing to define and refine the performance parameters. HGD technology is now available for field implementation and treatment of installations contaminated with explosive materials or chemical warfare agents.

HGD technology was developed and demonstrated as follows:

- In 1987, a pilot-scale study[2] for HGD technology using samples spiked with chemical warfare agent was conducted at Dugway Proving Ground, Utah. This controlled study successfully demonstrated the ability of the HGD technology to decontaminate agent from concrete and steel.

- Based on these results, pilot-scale tests[3] using the HGD technology to treat contamination with explosive materials were conducted at the Cornhusker Army Ammunition Plant in 1989. The Cornhusker test results indicated that the HGD technology seemed to be effective, but more studies were needed for application to explosive materials.

- Successful pilot-scale tests[4] were conducted in 1990 at Hawthorne Army Ammunition Plant for equipment, piping, and metal debris, including shell casings, contaminated with explosive materials. These studies defined HGD parameters for treatment of materials contaminated with explosive materials.

- Additional demonstration studies[5] were conducted in 1994 at Hawthorne for explosives contained within munitions, such as ship mines, depth bombs, and 106-mm and 5-inch projectiles. These latter Hawthorne results were successful, but indicated that equipment optimization should be further explored for explosive munitions applications.

- In 1994, a field demonstration[6] of HGD technology for facility and process equipment was successful in treating chemical warfare agent contamination at the Rocky Mountain Arsenal. This field demonstration provided HGD performance parameters for decontamination of former chemical agent installations.

- In 1995, validation testing for optimization of equipment using HGD technology for treatment of piping and debris contaminated with explosive material was conducted at the Alabama Army Ammunition Plant[7,8]. This validation testing provides HGD performance parameters for decontamination of former explosive materials installations.

This body of process development and demonstration has defined the parameters for successful application of HGD technology. *In situ* HGD technology for treatment of equipment, piping, and facilities contaminated with explosive materials is most effective based on achieving 600°F for a minimum six-hour soak period. Achieving these treatment parameters results in the following expected decontamination performance:

Explosive Contaminate	HGD Removal Efficiency
2,4,6-Trinitrotoluene (TNT)	99.9%
Tetryl	99.999%
RDX	99.99%

2.4 APPLICABILITY OF HOT GAS DECONTAMINATION TECHNOLOGY FOR EXPLOSIVES CONTAMINATED EQUIPMENT AND FACILITIES

The HGD process is applicable to explosives contaminated equipment and buildings used in manufacture packing, packaging, storage, maintenance, preservation, renovation, and demilitarization of ammunition or explosives. Many of these buildings housed dry and wet explosives operations and equipment. Dry operations were very dusty, and as a result, floors, walls and ceiling joists became contaminated with explosive dust.

Decontamination of these facilities and equipment must be undertaken in a safe, responsible and environmentally acceptable manner. As such, there are certain conditions which the Hot Gas Decontamination system may not be applicable, or where additional safety or environmental controls must be implemented prior to application of the HGD process. This is the case when the application of heat at temperatures of 600°F or less may cause undue safety or environmental risk.

Some specific cases or conditions where this may occur (and the mitigating pretreatment measures to accommodate use of Hot Gas Decontamination) include:

- If a substantial amount of explosive material is confined in a vessel, pipe or other confined location, the explosive has a potential to detonate when heated under confinement. Equipment containing high levels of residual explosives (i.e., greater than 12 to 15 percent) present an explosive hazard and require special consideration. If such a situation is encountered at a site being decontaminated, the equipment and confined explosive material must be cut out and removed before application of HGD process. Note that threaded pipe and joints in this situation should be cut out and not unthreaded, due to explosive hazard. Similarly, HGD of high level explosives contaminated soil *in-situ* is not appropriate due to explosion potential caused by confinement of explosives in the soil.

- The Hot Gas Decontamination process as proposed will not decontaminate High Melting Explosives (HMX) contamination, because the temperature/time criteria for decontamination of HMX will not be met.

- Friable asbestos should not be treated with the HGD process due to potential for dispersion of asbestos. Prior HGD projects have been conducted with transite siding in building materials, with no adverse environmental effects. Friable asbestos must be removed according to regulatory requirements prior to application of HGD technology.

- Hot Gas Decontamination is not appropriate for equipment or facilities with paint containing PCBs or lead. The PCB or lead in paint will volatilize when exposed to elevated temperatures. In this instance, PCB or lead-containing paint should be removed in accordance with applicable state and federal regulations. Similarly, PCB oil or PCB residue in vessels from prior spills must be properly removed or remediated prior to Hot Gas Decontamination.

- Galvanized sheet metal, when heated above 700°F, releases toxic vapor emissions. To use HGD in this case, the galvanized sheet metal must be insulated from the hot burner gas or the temperature of the hot burner gas restricted to well below 700°F.

- Electrical wiring, motors, and wood are not appropriate materials for HGD due to combustibility of the materials. These must be removed prior to initiating HGD.

- There is a public health risk associated with pigeon and other vermin droppings regarding exposure of workers to bacterial virus. Such wastes must be properly removed prior to workers installing the HGD system.

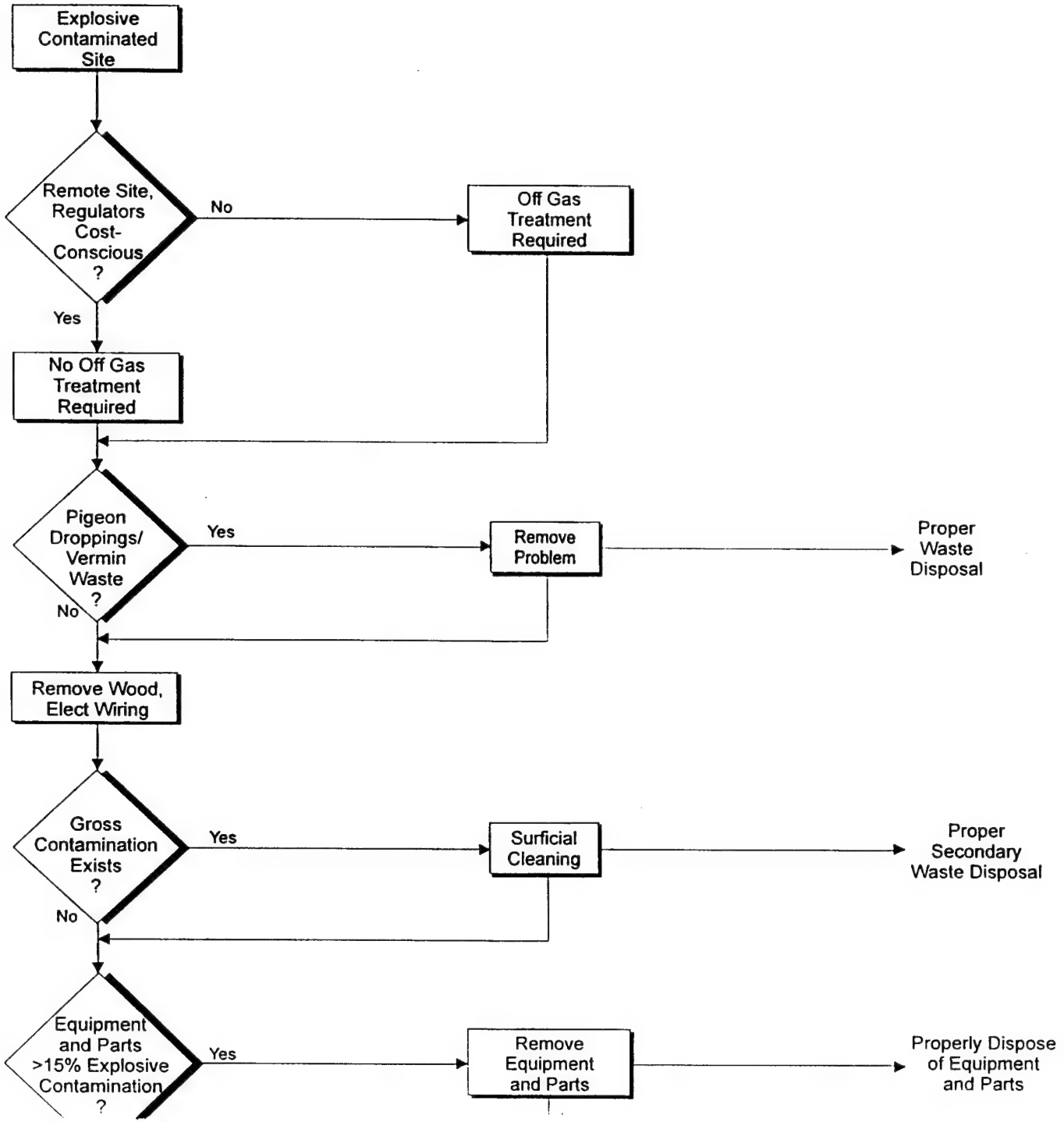
- Broken windows require replacement or should be closed with fireboard prior to HGD.

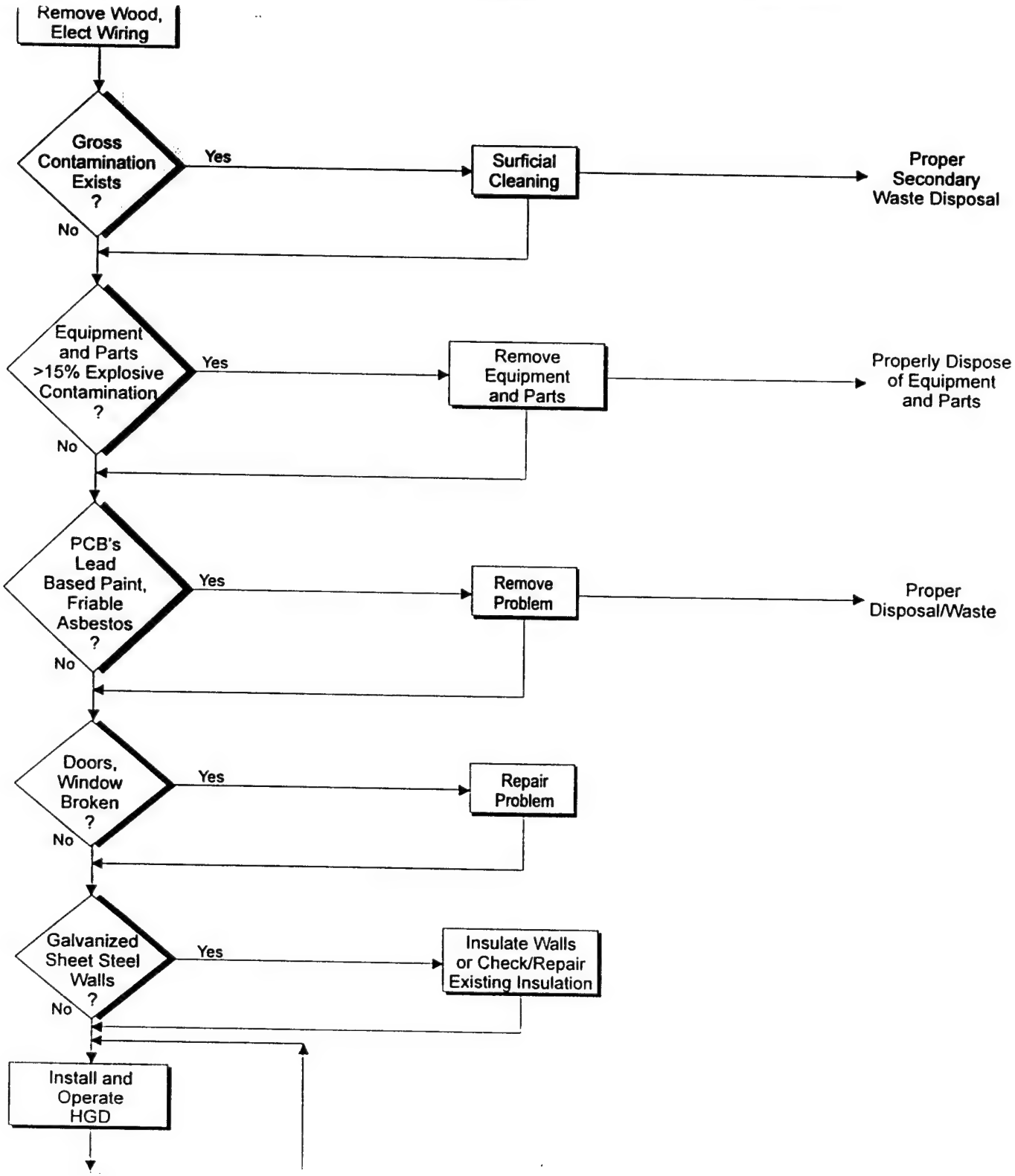
- In some instances where gross contamination exists, facilities and equipment may require surface cleaning to remove gross contamination, and to create a safe worker atmosphere for installation of the HGD system.

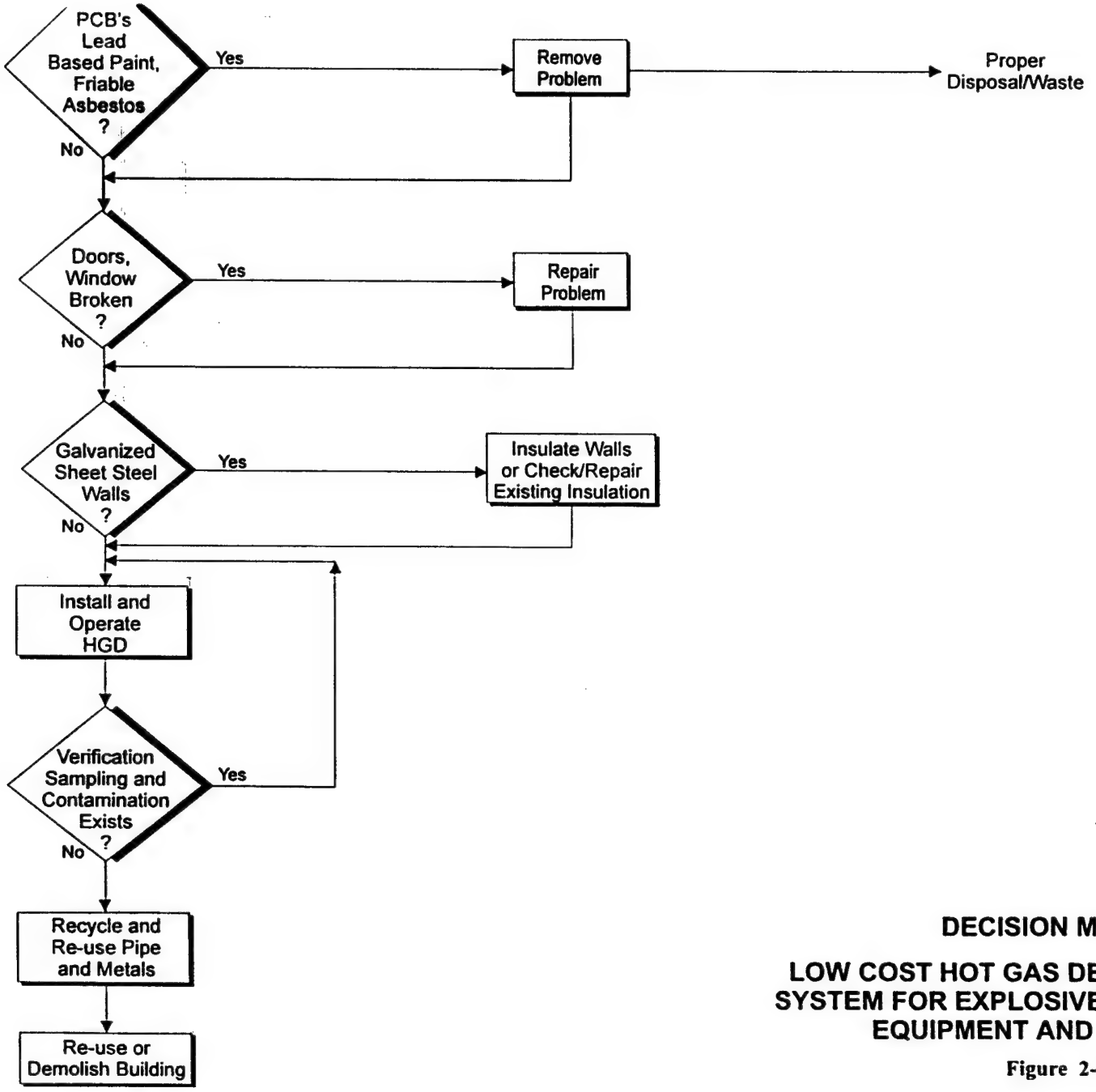
In situ HGD technology has been developed as an acceptable and safe alternative to 5X treatment for installations and the contained contaminated equipment and piping. *In situ* HGD technology is a lower cost alternative to *ex situ* 5X treatment for contaminated equipment and materials, and reduces the environmental and safety risks.

The scope of this Design Guidance Manual is confined to the use of HGD technology in the decontamination of facilities and equipment used only in the manufacture, maintenance, renovation, demilitarization, preservation, packing and packaging or storage of ammunition and explosives. As such the manual does not address in detail the specific remediation actions required for other environmental concerns listed above which may be encountered at a typical site.

A decision matrix and Logic Flow Diagram regarding the applicability of HGD technology at sites with multiple environmental contaminants of concerns is presented in Figure 2-1.


Explosive Contaminated Site
Remote Site, Regulators Cost-Conscious ?
No
Off Gas Treatment Required
Yes
No Off Gas Treatment Required
Pigeon Droppings/ Vermin Waste ?
Yes
Remove Problem
Proper Waste Disposal
No
Remove Wood, Elect Wiring
Gross Contamination Exists ?
Yes
Surficial Cleaning
Proper Secondary Waste Disposal
No
Equipment and Parts >15% Explosive Contamination ?
Yes
Remove Equipment and Parts
Properly Dispose of Equipment and Parts


Remove Wood, Elect Wiring
Gross Contamination Exists ?
Yes
No
Surficial Cleaning
Proper Secondary Waste Disposal
Equipment and Parts >15% Explosive Contamination ?
Yes
No
Remove Equipment and Parts
Properly Dispose of Equipment and Parts
PCB's Lead Based Paint, Friable Asbestos ?
Yes
No
Remove Problem
Proper Disposal/Waste
Doors, Window Broken ?
Yes
No
Repair Problem
Galvanized Sheet Steel Walls ?
Yes
No
Insulate Walls or Check/Repair Existing Insulation
Install and Operate HGD



DECISION MATRIX

LOW COST HOT GAS DECONTAMINATION SYSTEM FOR EXPLOSIVES CONTAMINATED EQUIPMENT AND FACILITIES

Figure 2-1

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SECTION 3

PRELIMINARY DESIGN

3.1 DESIGN CRITERIA

Previous demonstrations of the HGD technology explored the temperature-time relationship necessary for achieving 5X decontamination of explosives contaminated equipment and facilities. The HGD technology process utilizes low temperature heat soak to decontaminate equipment and structures which have been operationally contaminated with explosives. Under the heated conditions, the explosives residues in the target area are volatilized and thermally degraded in place. Decontamination of the equipment and facility is accomplished by maintaining the soak temperature over the specified time period required to meet the decontamination levels.

Results from tests at Hawthorne Army Depot[5] indicate a temperature between 550°F and 600°F for a 6-hour soak was required. Test results from Alabama Army Ammunition Plant[7,8] indicate the optimum operating conditions for achieving complete destruction of TNT, RDX, tetryl, and their breakdown constituents (i.e., to levels below method detection limits) were 600°F with a 1-hour soak. A conservative analysis of the results of prior HGD technology demonstrations indicated that a heat soak of the contaminated equipment and facilities at 600°F for 6 hours was required to consistently achieve 5X level of decontamination for a range of explosives contaminants. As a result, the primary criteria used for development of preliminary engineering and cost information in this report is heat exposure of the explosives contaminated target area to 600°F for a period of 6 hours.

A second engineering design criteria was also established for protection of the public health and the environment while conducting HGD. A temperature-time criteria for off-gas treatment (if required on a site-specific basis) was demonstrated in prior projects to be 1800°F for 2 seconds residence time. A lower temperature or residence time may be sufficient to eliminate contaminants from off-gas from an HGD system, but this analysis was not addressed in prior demonstrations. As a result, a temperature-time criteria for a thermal oxidizer for off-gas treatment (if required) is 1800°F for 2 seconds residence time, as previously demonstrated to effectively remove contaminants of concern from HGD off-gas. Note that a thermal oxidizer may not be required at all locations, as will be addressed later in this manual.

3.2 DESCRIPTION OF TARGET FACILITY

This design manual was developed using a model facility with explosives residue contamination to prepare technical and cost data. The model HGD target area includes a contaminated building and equipment, including contaminated walls, concrete floor, and process equipment in place.

The Explosives Washout Plant at the Umatilla Chemical Depot (UMCD), a U.S. Army ordnance depot in Umatilla, Oregon which is planned for closure under the Base Realignment and Closure (BRAC) Act, was selected as the target model facility. A substantial amount of information regarding the geometrical configuration, materials of construction, amount of contamination, and history of the UMCD Explosives Washout Plant is readily available[9,10]. The Explosives Washout Plant removed and recovered explosives from munitions using a hot water system. The plant consisted of two adjacent buildings and an attached shed. The washout building was a single story building 81 feet long by 32 feet wide by 31 feet high. A floor plan for the UMCD Explosives Washout Plant is presented in Figure 3-1. The adjacent pelletizer building was used to separate, pelletize, and dry recovered explosives. This building, two stories with concrete floors on both stories, was 32 feet long by 21 feet wide by 25 feet high. A 20 by 22 foot shed was attached to the pelletizer building. The equipment in the buildings included numerous tanks, pipe, duct, pumps, racks, pelletizer equipment, a crane, and other equipment. The total amount of floor space requiring decontamination between the two buildings and shed is approximately 4400 square feet (ft^2), which includes the second story of the pelletizer building.

The characteristics of the model facility used to develop engineering data, equipment sizing, and preliminary cost estimate for a low cost HGD process system include:

- A steel building with concrete floor containing process equipment used to manufacture or process explosives (i.e., vessels, piping). The floor and equipment are contaminated with explosive material;
- The building has metal siding, a metal roof, and rooms separated by concrete blast walls. Note that the building walls for the Washout Building at UMCD are galvanized, and must be insulated to hold temperatures below 700°F as previously discussed;
- A concrete floor that is 8 inches thick with control joints and stress cracks in the floor. The contamination has migrated downward through the depth of the floor over time;
- Overhead piping and ceiling beams with explosive dust on the outside;
- The building is not painted, equipment and concrete floors are painted;
- Contaminated process equipment is in close quarters and has very little working room (i.e., small clearances between equipment and walls); and
- No available utilities at the site.

Using building and room configurations combined with capacities of available off-the-shelf equipment, a size of the target area was selected at 1300 ft^2 for a single HGD run. As discussed below, larger target areas will be decontaminated with multiple HGD runs.

3.3 GENERAL FUNCTIONAL REQUIREMENTS

Based on the knowledge and experience gained from the field demonstrations, the following functional requirements ensure the cost-effective implementation of the HGD process:

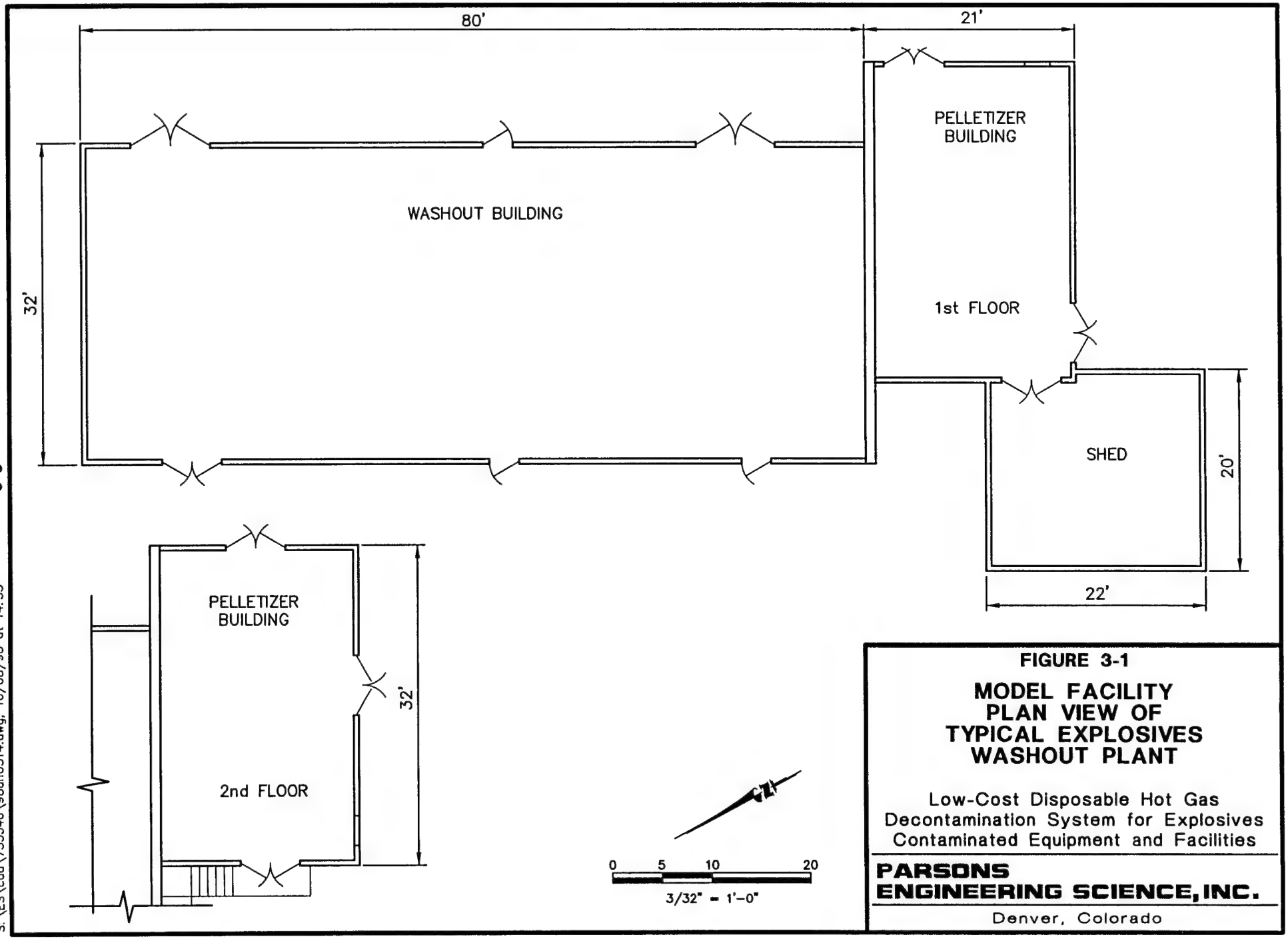

FIGURE 3-1

MODEL FACILITY PLAN VIEW OF TYPICAL EXPLOSIVES WASHOUT PLANT

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

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Denver, Colorado

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- The design must effectively meet decontamination requirements while ensuring the health and safety of workers and the general public, and just protect the environment;
- The confidence and approval of regulatory agency personnel must be gained;
- The design must be simple and repeatable;
- Provisions to use locally available stock items, standard equipment, and expendables to minimize cost must be included;
- Specifications shall identify low cost and standard disposable materials of construction;
- Basic control systems and operations are to be used and maintained;
- Maximize the use of leased and/or disposable equipment for supporting a one-time use and short project life;
- Eliminate research and development add-ons;
- Include redundant safety and instrument systems only where necessary for safe, effective, and environmentally acceptable construction and operation;
- Use *in-situ* rather than *ex-situ* (i.e. demolish or remove and treat off-site) for treating facilities and equipment;
- Minimize manpower and utility requirements;
- Perform necessary preparation steps to safely conduct HGD and minimize hazardous byproducts; and
- Provide emissions monitoring (continuous or grab samples) as required to meet regulatory standards. Monitoring requirements are developed on a case by case basis as required by the local regulatory agency.

3.4 OTHER CONSIDERATIONS FOR USE OF HGD TECHNOLOGY

In addition to the information previously discussed, several other considerations should be addressed in the feasibility planning stage to make an informed decision to implement HGD or an alternate technology. The amount, extent, and type of explosives contamination; other types of environmental problems; and the condition of the facility must be sufficiently characterized early in the planning process to ensure that enough information is available to make valid decisions.

Several considerations should be evaluated when making a go/no go decision for using HGD technology, implementing the technology, or HGD on a part of a facility including:

- Characterization of contamination of a site or facility results from sampling and analysis delineating the extent and type of contamination. Core sampling of the depth of the concrete floor and wipe sampling of contaminated surfaces is required. This information is generally set forth in a Sampling and Analysis Plan for a specific site. Approved EPA

methods for chemical analysis that are presented in published literature (Oresik et al)[11] must be used. The detailed requirements for facility characterization are not addressed in this design guidance manual.

- The economics related to the end disposition or use of materials and the disposal or reuse alternatives such as landfill, recycle scrap, or salvage equipment should be considered.

- The level of decontamination required depends on the end use and final disposition of the materials, equipment, and facility. For example, the decontamination requirements for materials to be landfilled (concrete or soil) in on-post hazardous landfills typically are not as stringent as the 5X decontamination requirements for materials to be re-used, salvaged, or recycled.

- Worker health and safety is a primary project criteria. Local fire codes and site safety requirements shall be reviewed and complied with. For example, temporary fuel storage tanks (propane or other fuel) and other hazardous materials must comply with codes and regulatory requirements, including separation distances. A project-specific Health and Safety Plan is required to address the installation and operation of the HGD process for each facility. The current or past uses of adjacent facilities should be considered when identifying the project-specific safety requirements.

- After HGD, sampling and analysis for verification of effectiveness will indicate whether the HGD has been effective, whether the scrap metal is suitable for recycle, and whether the building is suitable for reuse or dismantlement. This is set forth in a Sampling and Analysis Plan for the site. Approved EPA methods for chemical analysis must be used as presented in published literature (Oresik et al)[11]. The detailed requirements for post-HGD facility characterization are not addressed in this design guidance manual.

The application of HGD technology may vary at specific sites due to types of explosives contamination and differences in site characteristics, but the principles for using the HGD technology still apply. The 1300 ft^2 area is generally a good size area to implement HGD, but the HGD can readily be engineered for larger or smaller areas. Using the 1300 ft^2 design, larger target areas are decontaminated in phases and parcels of 1300 ft^2 or less.

3.5 BASELINE HGD SYSTEM WITH NO OFF-GAS TREATMENT

The Baseline HGD System presented here is a gas-fired burner system heating a target explosives contaminated building and equipment with no off-gas treatment or monitoring. The HGD system with no off-gas treatment is the most basic HGD system requiring a heat source, a thermal blanket and supports, protective insulation, a thermocouple array, a data acquisition system, a leased power supply, and a basic control system. This system can provide a heat soak to the target contaminated area at a temperature of 600°F. This is inherently a low cost method to decontaminate explosives contaminated buildings and equipment.

All of the previous demonstrations of the HGD technology used an off-gas treatment system to treat volatilized emissions. Generally speaking, it is the off-gas treatment system which is very expensive and drives the overall system cost upwards. The off-gas treatment system typically can be 25 to 40 percent of the overall system cost. As a one time decontamination action, off-gas treatment is not an absolute requirement by regulators at all locations. This was demonstrated by recent (1996) permission by the Oregon Department of Environment

Quality to open burn (flash flame) the Explosives Washout Building at Umatilla Chemical Depot, Umatilla Oregon without emissions control or treatment. The requirement for an off-gas treatment system must be evaluated on a case-by-case basis considering the site location and distance away from populated areas and off-site receptors, and local and state regulatory standards. Environmental permitting, emissions limitations, and monitoring (continuous or intermittent) requirements will be determined on a case-by-case basis. Use of emissions estimates, air modeling and fate and transport models can be used to make a case for HGD with no off-gas treatment. Operational controls (such as wind speed and direction restrictions) can be placed on the system to further promote the HGD system without off-gas treatment concept. For example, in a remote location with a reasonable regulatory oversight and no nearby receptors, a HGD system with no off-gas treatment may be judged acceptable as a quick, low cost method to remove contamination.

A Process Flow Diagram of the Baseline HGD system is shown in Figure 3-2. Two air heaters are is used to heat the target area. Two standard high velocity recirculating fan-forced air heater(s) fueled by propane or natural gas with a capacity of 1.5 million BTU/hr (each) were selected for process heating. The flame of the recirculating heaters is at a temperature of 2000°F projecting 4 feet into the target area. The high velocity forced air heaters recirculate the air in the target area back towards the burner flame, and expose the air and volatilized contaminants to the burner flame. The recirculating-type burner spreads more uniform heat throughout the primary target area (equipment and floor), and permits the off-gas and volatilized contaminants to be exposed to high temperatures for several minutes. The combined capacity of the air heater fan(s) should be sized to provide a total circulation rate of approximately 500 cubic feet per minute (cfm) (250 cfm each). Although not necessarily required at all locations, an exhaust stack has been included in the design presented here. An equipment list itemizing the materials and equipment required for the low-cost Hot Gas Decontamination System for Explosives contaminated Facilities and Equipment is presented in Table 3-1.

The heaters are placed through the outside wall of the target area to implement the recirculating feature of the burners. The two heaters are placed in diametrically opposite corners in the target area to provide better distribution of heat. A penetration through the building wall (one each heater) is required to inject the hot gas from the heaters to the target area. A window or door opening may be modified for this purpose. The building and building materials should be well insulated near the burner location. A leased propane fuel tank will provide fuel for the burners. The energy balance calculations which support the sizing of the air heaters are presented as Appendix A.

The concrete floor of the building is the largest heat sink in the target area. If contamination has migrated downward through control joints and stress cracks in the floor, decontamination of the depth of the floor is required which is by far the most difficult area of the target site to heat. In the model facility used here, this is the case. To minimize heat losses and direct heat to the floor, a fire resistant thermal fabric is suspended approximately 2 feet above the floor and draped over equipment and pipe to contain the hot air. The thermal blanket is supported by a makeshift metal or block supports (scrap or new sheet metal siding or roofing supported by cinder blocks, steel struts or angle iron) to form a plenum. The thermal blanket, lower building walls, and concrete floor form a chamber (somewhat like a furnace chamber) for containing the hot air. The target area is allowed to exhaust through the thermal blanket (plenum) into the upper room through strategically placed penetrations to permit heat to migrate to the upper walls and ceiling. The exhaust penetrations are strategically placed in

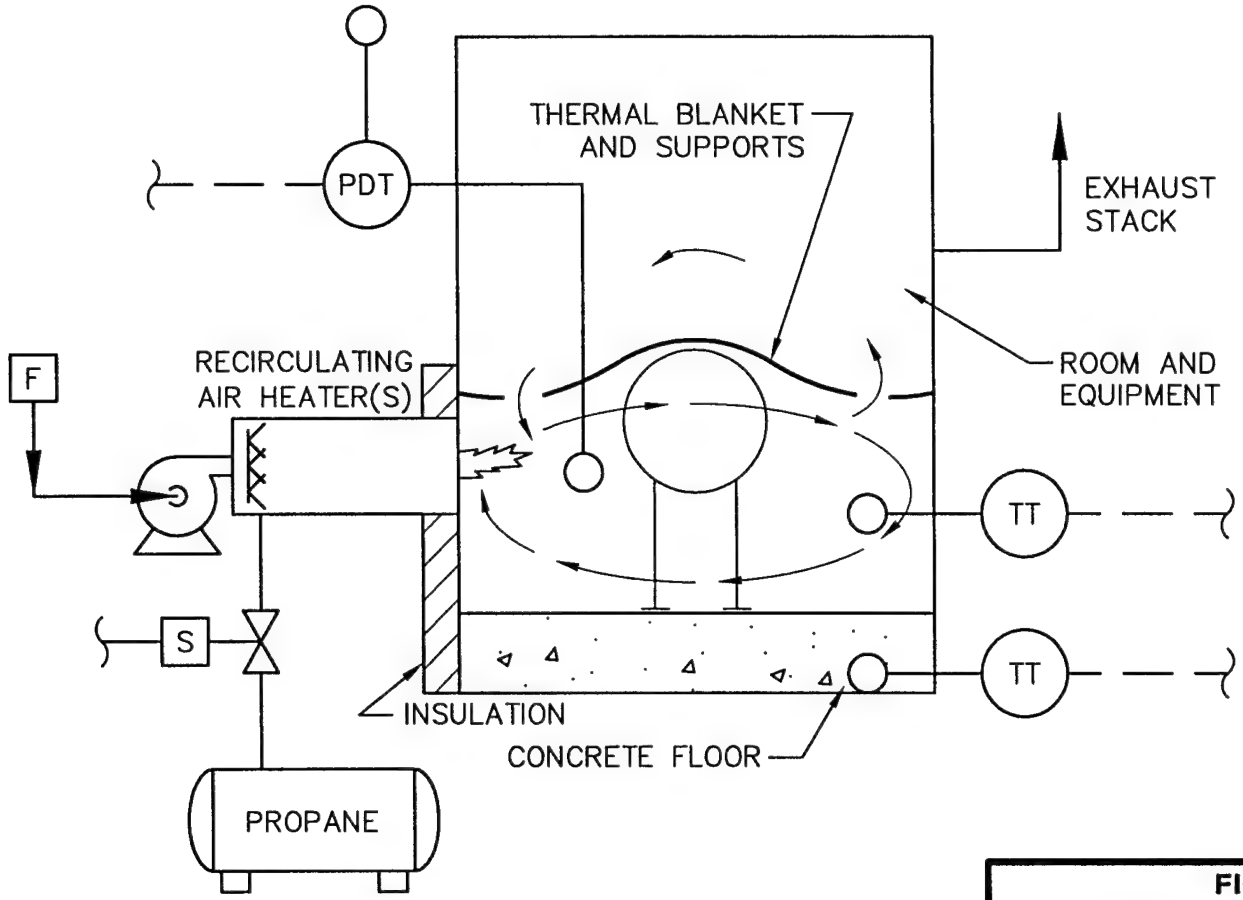

FIGURE 3-2

PRELIMINARY DESIGN
PROCESS FLOW DIAGRAM
BASELINE HGD SYSTEM
NO OFF-GAS TREATMENT

Low-Cost Disposable Hot Gas
Decontamination System for Explosives
Contaminated Equipment and Facilities

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TABLE 3-1
EQUIPMENT LIST
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Quantity	Description
1 EA	Generator, portable, 75 KVA, 120/208, 3 phase, trailer mounted.
1 EA	2000 gal Convault fuel tank (generator), w/ stairs, base and pump.
100 LF	1-1/2" Schedule 40, carbon steel pipe with elbows and miscellaneous fittings
2 EA	1-1/2" Ball valve, carbon steel, screwed
2000 SF	Flame resistant blanket with supporting steel bases and sheet steel roofing material.
1 EA	Stack, 20" diameter x 25 ft. tall comprised of base flange, inlet section constructed with 5' long sections and clamps, with guy wires.
2 EA	Hauck SVG high velocity recirculating burner assembly with gas train and controls.
12 EA	Thermocouples w/ 125' of high temperature lead wire, per assembly
1 EA	Data Acquisition System, consisting of personal computer and peripherals.
1 EA	Distribution Panel, 60 amp, 120/240volt, NEMA 3R enclosure, and 6 branch circuit breakers.
1 EA	Shunt trip, main circuit breaker
1 EA	Ground rod, 5/8" x 10 ft., copper clad
1 EA	Compound starter, 240 Volt, 1 phase, w/non fused disconnect switch and miscellaneous electrical materials.

opposite corners of the target area to enhance hot air circulation. A penetration is placed in the plenum directly above the burner flame to avoid over-heating the plenum materials and further promote recirculation. A cross-section of the target area during HGD is presented in Figure 3.3. In some instances, it may be advantageous to cut down elevated pipe or duct and lay on the floor, or relocate equipment inside the target area, to accommodate the thermal blanket or to increase heat and time exposure of equipment to HGD.

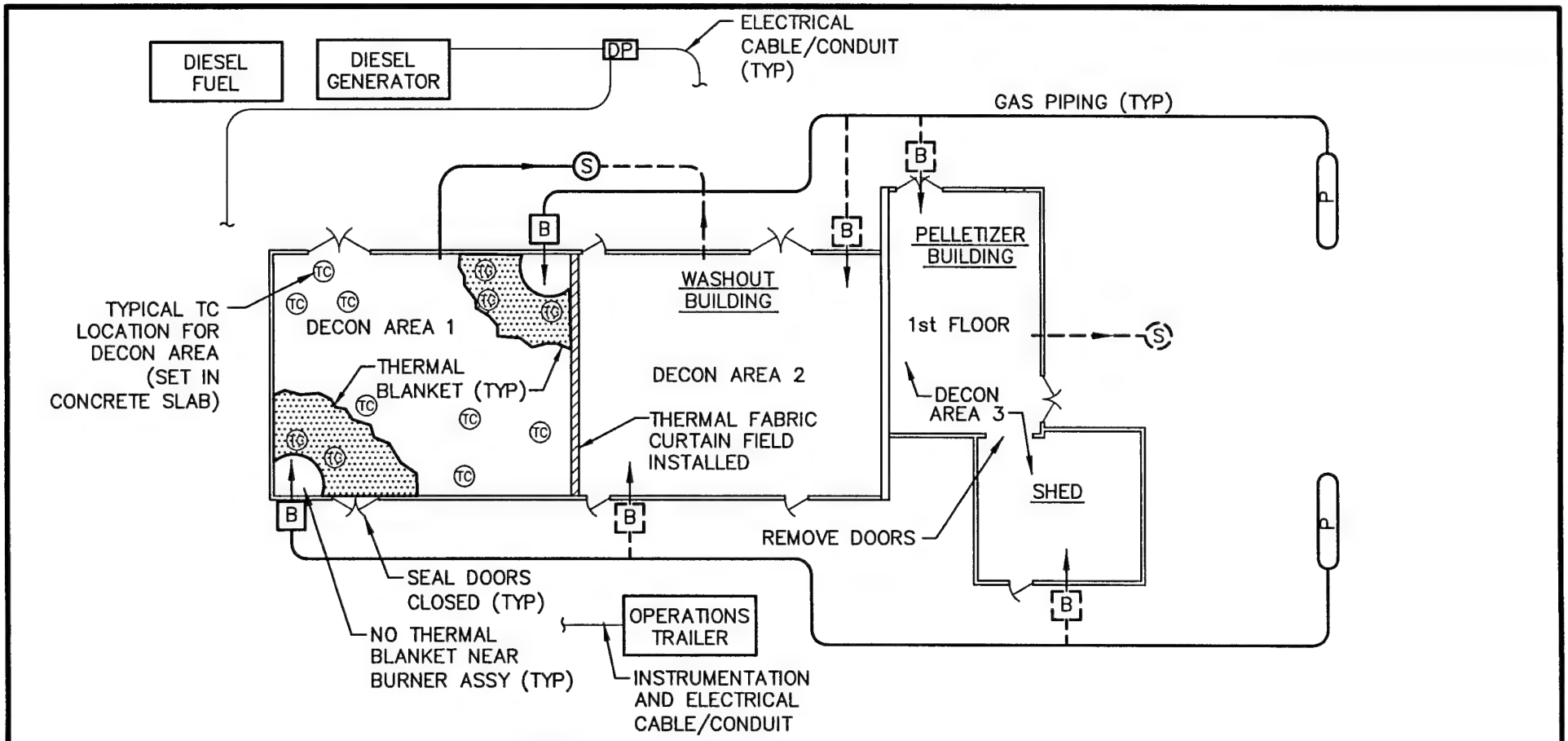
Thermocouples with temperature transmitters are interlocked to the air heater fuel supply to control the programmed soak temperature of the concrete, equipment, or skin temperature. A pressure transmitter may be interlocked to a motorized damper on the rigid portion of the exhaust stack to prevent over pressurization of the target area. Thermocouples are strategically placed at expected cooler locations (cored to the outside surface (bottom) of concrete floors near the corners; away from the burners; or near massive heat sinks such as concrete blast walls). During heatup, the thermocouples indicate when their location has met the design criteria (600°F), and the 6-hour heat soak can commence. When all of the thermocouples reach 600°F for a 6-hour duration, the heat soak is complete and the cool down period is initiated. This is accomplished by running the heaters' combustion air fan with the gas burner off and the exhaust stack damper in the wide-open position. This arrangement will force cooler ambient air through the target area. The thermocouple signals are transmitted to a remote control station for recording and decision-making. The number of thermocouples required is based on the configuration of the site and should be minimized to that which is necessary. It is estimated that a maximum of 12 thermocouples will be required. The remote readout is a standard personal computer located in a leased construction trailer.

For areas larger than 1300 ft^2 (the nominal design size for the target area selected for the model facility), the HGD system is moved from one room of 1300 ft^2 area to another and the process repeated. Concrete blast walls or steel walls can be used to define target area limits. For individual rooms larger than 1300 ft^2 (such as the washout building in the model facility), a vertical curtain can be draped using the fire resistant thermal blanket. At the model target facility, the HGD process would be operated four times and HGD equipment relocated to four separate areas of 1300 ft^2 or less as follows:

- Decon Area 1 - One half of the explosives washout building (1300 ft^2),
- Decon Area 2 - The other half of the explosives washout building (1300 ft^2),
- Decon Area 3 - First floor of the pelletizer building and attached shed (1100 ft^2), and
- Decon Area 4 - Second floor of the pelletizer building (700 ft^2).

In four passes, a total of 4400 ft^2 at the model facility would be decontaminated. A Site Plan of the Baseline HGD System implemented at Decon Area 1 of the model target facility is shown in Figure 3-4. Similarly, the Baseline HGD System relocated to Decon Areas 2, 3, and 4 are shown in phantom in Figure 3-4.

A simple control process is employed for ease of operation and installation. Instrumentation is configured for remote read-out, with local read-out being used only for set-up and test. Any operational equipment or instrumentation placed within the target area must be able to operate at elevated temperatures. Electrical power is provided by a leased diesel generator and fuel tank. An electrical one-line diagram of the baseline system is presented in Figure 3-5.



NOTES:
1. SITE IS INCREMENTALLY DECONTAMINATED. EQUIPMENT IS SHOWN FOR DECON AREA 1.
2. EQUIPMENT SHOWN IN PHANTOM REPRESENTS LOCATIONS FOR SUBSEQUENT DECONTAMINATION OF DECON AREAS 2 AND 3
3. 2ND FLOOR OF PELLETIZER BUILDING IS DECON AREA 4, NOT SHOWN FOR CLARITY.
4. ALL EQUIPMENT LOCATIONS SUBJECT TO CODE COMPLIANCE
5. EACH DECON AREA REQUIRES NEW THERMOCOUPLES INSTALLATION SIMILAR TO DECON AREA 1.

LEGEND

- P — PROPANE TANK
- B — BURNER ASSEMBLY
- TO — THERMAL OXIDIZER
- TC — THERMOCOUPLE
- DP — ELECTRICAL DISTRIBUTION PANEL
- S — STACK

GTI

0 10' 20' 40'

SCALE: 1"=20'

FIGURE 3-3

SITE PLAN
BASELINE HGD SYSTEM
WITHOUT OFF GAS TREATMENT

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

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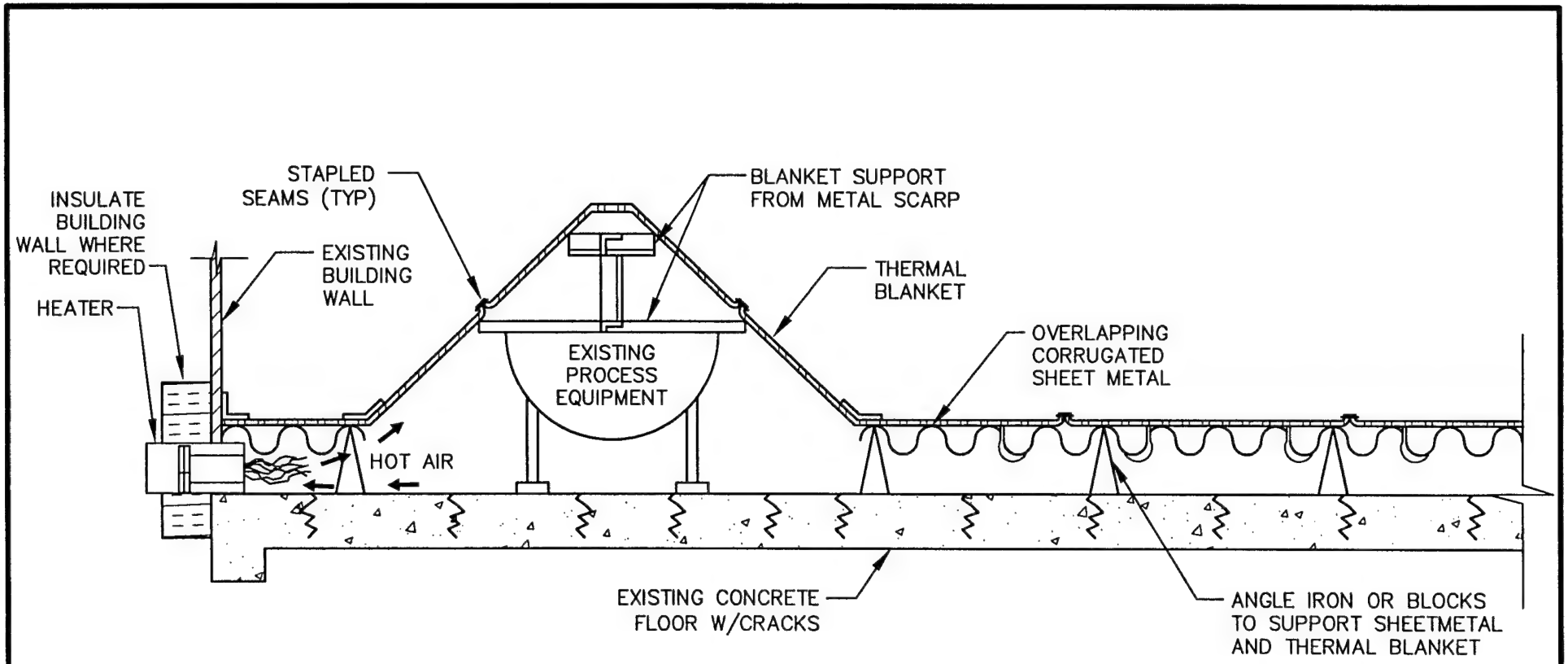

FIGURE 3-4

PRELIMINARY DESIGN ELEVATION VIEW OF TARGET AREA

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

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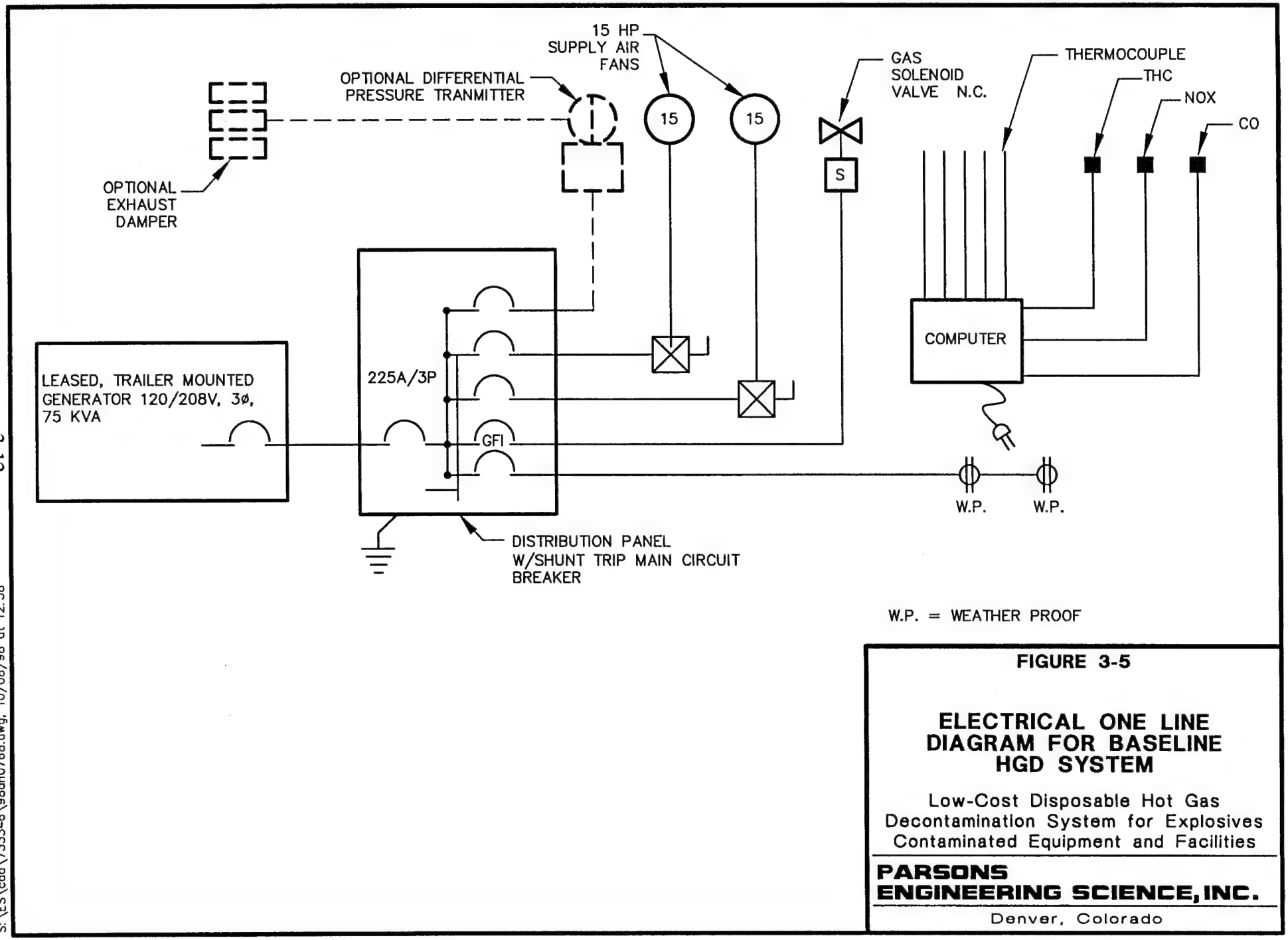

FIGURE 3-5

ELECTRICAL ONE LINE DIAGRAM FOR BASELINE HGD SYSTEM

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

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In the baseline HGD system, the off-gas and volatilized contaminants are exposed to elevated temperatures (600°F to 800°F) for a substantial residence time (over an hour for the model facility) due to the recirculating feature of the burners. In addition, the system is configured to draw off-gas through the 2000°F burner flame. These features provide partial (possibly complete) thermal destruction treatment to the volatilized contaminants. The concept is that the recirculation system takes the place of off-gas treatment. There is no published data indicating the effectiveness of this treatment to destroy the volatilized contaminants. However, the recirculation feature causes the off-gas treatment system (if required) to be somewhat a redundant treatment system. This was demonstrated for a recirculating type HGD system treating chemical agent at the Field Demonstration of the Hot Gas Decontamination System for Chemical Agent at Rocky Mountain Arsenal[6]. In this case, DAAMS tube verification sampling the off-gas prior to thermal treatment indicated no mustard agent in the off-gas. A few positive readings found in continuous agent monitors during this demonstration were determined to be false positives upon verification sampling. The advantages of recirculating burners provide additional justification to delete the requirement for off-gas treatment for the HGD process, to reduce cost.

3.6 OPTION 1 - HOT GAS DECONTAMINATION SYSTEM WITH OFF-GAS TREATMENT

The Option 1 Hot Gas Decontamination System with Off-Gas Treatment encompasses all of the features of the Baseline System, with the addition of a thermal oxidizer and negative pressure off-gas treatment system. An off-gas treatment system with monitoring significantly increases the cost, schedule, and complexity of a HGD system. The need for an off-gas treatment system must be evaluated on a case-by-case basis considering the proximity of the site to other occupied areas and local/state regulatory requirements. The permitting, emissions limitations, and monitoring (continuous or intermittent) requirements also must be determined on a case-by-case basis, depending on local regulators.

All of the previous demonstrations of the HGD technology used a thermal oxidizer operating at 1800°F for two seconds residence time. This off-gas treatment system has proven to be effective in removing volatilized contaminants of concern from exhaust from a HGD system. For this reason, thermal oxidizer design criteria of 1800°F for two seconds residence time have been adopted for Option 1 - HGD with Off-Gas Treatment.

Option 1 - HGD with Off-Gas Treatment has all of the components of the baseline system plus additional equipment and instrumentation necessary to maintain the target area under negative pressure and treat off-gas and volatilized contaminants in a thermal oxidizer. Negative pressure is maintained within the target area containment to prevent the escape of fugitive emissions and to direct the exhaust of off-gas to the thermal oxidation unit. An induced draft fan generates the negative pressure within the target area containment. A Process Flow Diagram of Option 1 - HGD with Off-Gas Treatment is presented in Figure 3-6. In four passes, a total of 4400 ft^2 at the model facility would be decontaminated. A Site Plan for the Option 1 HGD System implemented at Decon Areas 1 is shown in Figure 3-7. Site arrangements for Option 1 HGD at subsequently relocations to Decon Areas 2, 3, and 4 of the model facility are shown in phantom on Figure 3-7. An equipment list for Option 1 is presented in Table 3-2.

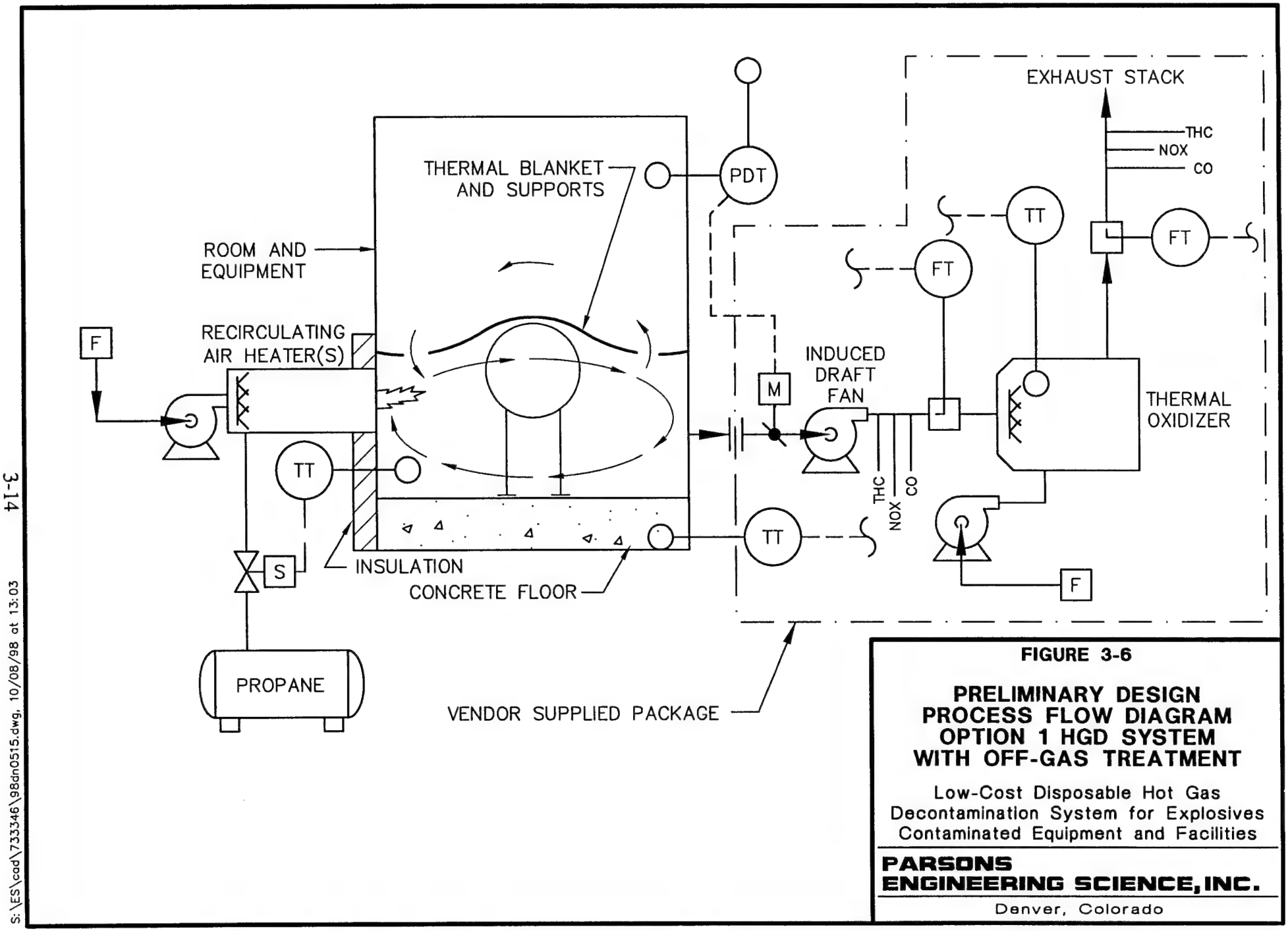

FIGURE 3-6

PRELIMINARY DESIGN
PROCESS FLOW DIAGRAM
OPTION 1 HGD SYSTEM
WITH OFF-GAS TREATMENT

Low-Cost Disposable Hot Gas
Decontamination System for Explosives
Contaminated Equipment and Facilities

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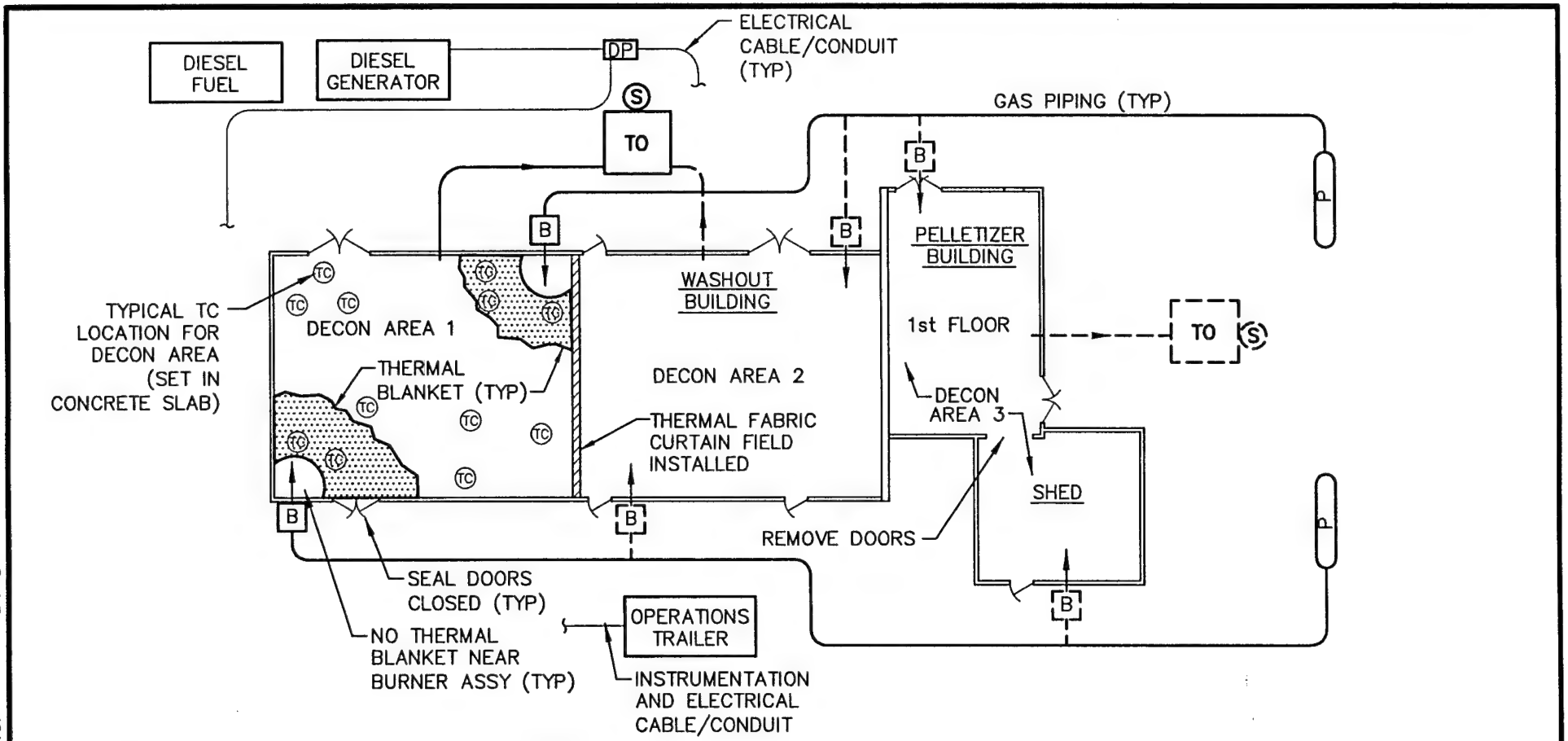

NOTES:
1. SITE IS INCREMENTALLY DECONTAMINATED. EQUIPMENT IS SHOWN FOR DECON AREA 1.
2. EQUIPMENT SHOWN IN PHANTOM REPRESENTS LOCATIONS FOR SUBSEQUENT DECONTAMINATION OF DECON AREAS 2 AND 3
3. 2ND FLOOR OF PELLETIZER BUILDING IS DECON AREA 4, NOT SHOWN FOR CLARITY.
4. ALL EQUIPMENT LOCATIONS SUBJECT TO CODE COMPLIANCE
5. EACH DECON AREA REQUIRES NEW THERMOCOUPLES INSTALLATION SIMILAR TO DECON AREA 1.

LEGEND

- P — PROPANE TANK
- B — BURNER ASSEMBLY
- TO — THERMAL OXIDIZER
- TC — THERMOCOUPLE
- DP — ELECTRICAL DISTRIBUTION PANEL
- S — STACK

0 10' 20' 40'

SCALE: 1"=20'

FIGURE 3-7

SITE PLAN
OPTION 1-HGD SYSTEM
WITH OFF-GAS TREATMENT

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

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TABLE 3-2
EQUIPMENT LIST
LOW-COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Quantity	Description
1	Generator, portable, 75 KVA, 120/208, 3 phase, trailer mounted.
1	2000 gal Convault fuel tank (generator), w/ stairs, base and pump.
100 ft.	1-1/2 inch Schedule 40, carbon steel pipe with elbows and miscellaneous fittings
2	1-1/2 ft. Ball valve, carbon steel, screwed
2000 ft^2	Flame resistant blanket with supporting steel bases and sheet steel roofing material.
2	Hauck SVG high velocity recirculating burner assembly with gas train and controls.
12	Thermocouples w/ 125 ft. of high temperature lead wire
1	Data Aquisition System, consisting of desktop computer and peripherals.
1	Distribution Panel, 60 amp, 120/240volt, NEMA 3R enclosure, and 6 branch circuit breakers.
1	Shunt trip, main cb, 60A/2P for above
1	Ground rod, 5/8" x 10 ft., copper clad
1	Compound starter, 240 Volt, 1 phase, w/non fused disconnect switch and miscellaneous electrical materials.
1	Thermal oxidizer assembly, skid mounted with stack, controls, and induced draft fan.

A thermal oxidizer which operates at 1800°F for two seconds residence time is not a stock item, and must be custom ordered. Standard thermal oxidizers are limited to a maximum of 1400°F for a half-second residence time. The thermal oxidizer must be operational at design capacity throughout the heat up, 6-hour heat soak, and cool down of the target area.

The induced draft fan operates at a greater volumetric capacity than the heater's combustion air fans in order to maintain the negative pressure. An induced draft fan capable of 600°F service operation is required to maintain a nominal negative pressure of 0.01 to 0.02 inches W.C. within the target area to ensure inward leakage of outside air. System negative pressure is controlled using a pressure transducer interlocked with a motorized damper on the inlet side of the induced draft fan. Flow transmitters and air sampling equipment are furnished with the thermal oxidizer package. An electrical one-line diagram of the Option 1 - HGD system with Off-Gas Treatment is presented in Figure 3-8.

Depending on the site location and regulatory requirements, the off-gas treatment system will have some level of continuous stack monitoring as a requirement. A basic continuous monitoring system has been selected for the model project presented here, which includes total hydrocarbons, nitrous oxides, and carbon monoxide monitors.

Standard thermal oxidizers, which are available for lease, operate at a maximum temperature of 1400°F with a half-second residence time, and do not meet the temperature time criteria previously established in prior HGD projects. There is no data to support the removal effectiveness of a 1400°F/half-second thermal unit in treating off-gas from an HGD project for explosives contamination. A substantial cost savings would be realized in the event that a standard (leased) 1400°F/half-second thermal unit was permitted by regulators at a particular location.

3.7 STANDARD DESIGN PACKAGE DRAWINGS AND SPECIFICATIONS

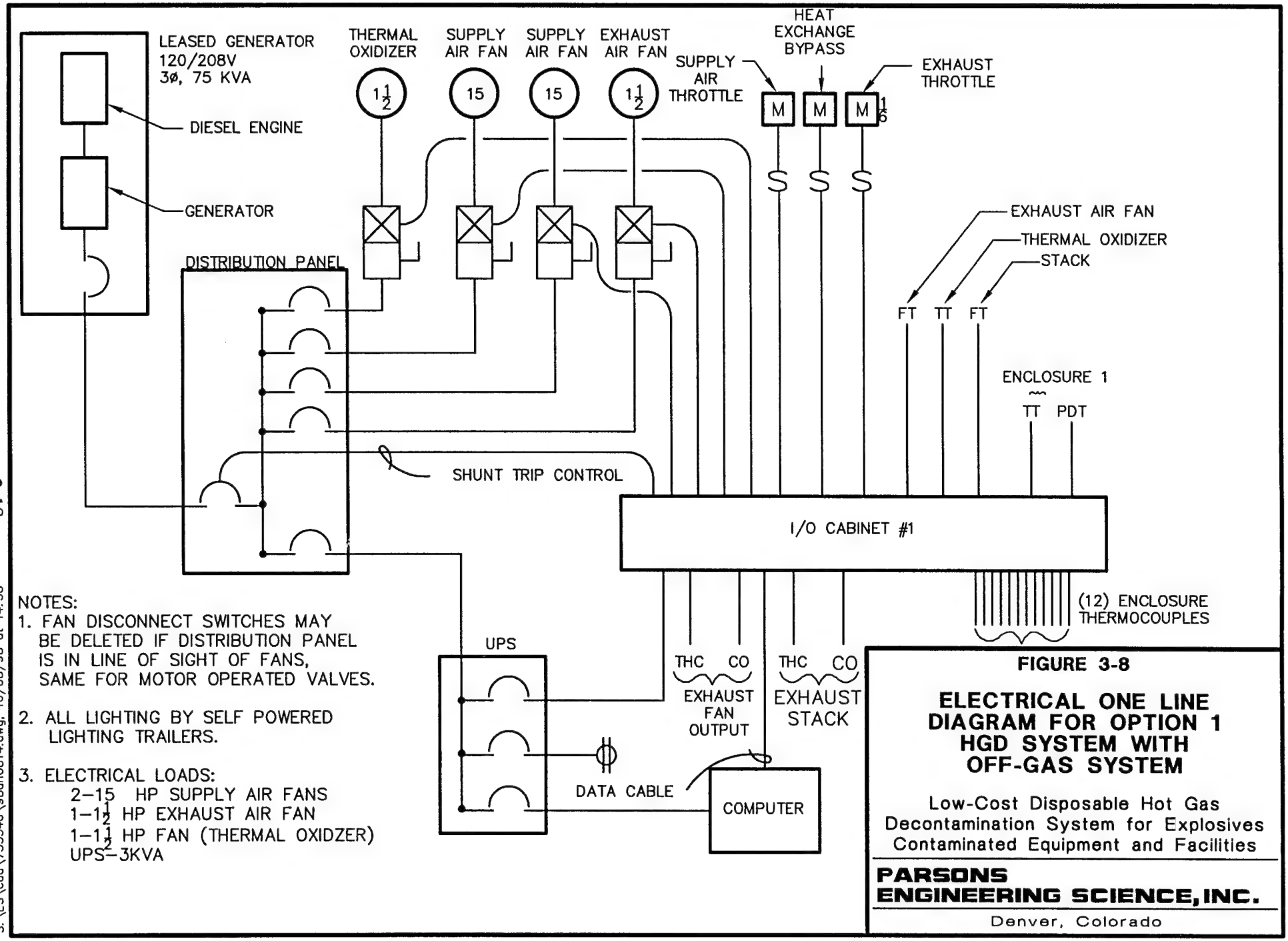
A drawing list and specification list for a design-build HGD system is presented in Table 3-3.

3.8 EQUIPMENT AND COMPONENTS

Equipment details, suppliers, and materials of construction used for the Baseline HGD System without Off-Gas Treatment and Option 1 - HGD System with Off-Gas Treatment are detailed below. Vendor cut sheets are presented in Appendix B.

3.8.1 Heaters and Controls

Recirculating air heaters were selected for the HGD system since they have the ability to heat and recirculate air within the target area. Recirculation of volatilized off-gas through or near the 2000°F burner flame provides thermal destruction of the contaminants while still in the target area, reducing or eliminating the need for off-gas treatment (or rendering off-gas treatment to be redundant). The recirculating burner selected is a Super Velocity Gas (SVG) Burner manufactured by Hauck Manufacturing Co. (Lebanon, Pennsylvania). The vendor can furnish the burner as a propane-fired, natural gas-fired, or oil-fired unit. A propane-fired burner was selected for this application, due to the design constraint of no available site utilities. The vendor can furnish the burner as a propane-fired, natural gas-fired, or oil-fired unit. A propane-fired burner was selected for this application, due to the design constraint of



NOTES:
1. FAN DISCONNECT SWITCHES MAY BE DELETED IF DISTRIBUTION PANEL IS IN LINE OF SIGHT OF FANS, SAME FOR MOTOR OPERATED VALVES.

2. ALL LIGHTING BY SELF POWERED LIGHTING TRAILERS.

3. ELECTRICAL LOADS:
   2–15 HP SUPPLY AIR FANS
   1–1½ HP EXHAUST AIR FAN
   1–1½ HP FAN (THERMAL OXIDZER)
   UPS–3KVA

FIGURE 3-8

ELECTRICAL ONE LINE DIAGRAM FOR OPTION 1 HGD SYSTEM WITH OFF-GAS SYSTEM

Low-Cost Disposable Hot Gas Decontamination System for Explosives Contaminated Equipment and Facilities

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

Table 3-3 Design Drawings and Specifications

Design Drawings	Specifications
Site Plan and Legend	Division 1: General Requirements Section 01010 - Summary of Work Section 01300 - Submittals
Process Flow Diagram	
Process and Instrumentation Diagram	Division 11: Equipment Section 11500 - Gas Fired Heater Section 11505 - Afterburner
New Equipment Envelope and Footprint (Plan and Elevation)	
Mechanical Systems Plan and Details	Division 13: Special Construction Section 13400 - General Instrumentation, Control and Monitoring Requirements and System Description Section 13410 - Panel Mounted and Field Mounted Instruments
Electrical/Instrumentation Plan and Details	
Miscellaneous Details	Division 15: Mechanical Section 15050 - Basic Mechanical Materials and Methods (Piping and Ductwork) Section 15250 - Mechanical Insulation Section 15500 - Heating and Ventilating
	Division 16: Electrical Section 16010 - General Electrical Requirements Section 16200 - Diesel Generator Set Section 16400 - Service and Distribution Section 16600 - Uninterruptible Power Systems

no available site utilities. The unit is furnished as a skid mounted assembly complete with gas trains and controls.

The recirculating air heater discussed above is the optimum choice for the Baseline HGD system (no off-gas treatment) particularly since the recirculating feature provides additional exposure of volatilized contaminants over time. The recirculating heater was also used in the Option 1 - HGD system (with Off-Gas Treatment) as presented here. There is some leeway in selection of heaters, in particular for Option 1, to further lower the HGD system cost using stock air heaters.

Stock air heaters which can achieve the HGD design criteria are available from a variety of sources, and can either be leased or purchased. Two vendors sources are as follows:

- U.S. Distributing, Inc. (Birmingham, Michigan) can furnish portable heaters for lease or purchase. A 700°F burner outlet temperature (minimum required burner outlet temperature to achieve 600°F in the target area) is a special order for U.S. Distributing, but can be furnished upon request.

- North American Manufacturing Company (Cleveland, Ohio) can furnish heaters for purchase only. The equipment is industrial grade, and is relatively high cost.

Honeywell has developed an inexpensive line of burner controls and dampers that are ideal for application with low cost HGD.

3.8.2 Thermal Blanket

To heat the concrete slab floor, a thermal blanket is used to contain the burner gas and heat circulating across the floor. The thermal blanket is supported with sheet metal and blocks approximately 2 feet off the floor to form a plenum, which holds the burner exhaust and heat down near the concrete floor. A high temperature textile fabric manufactured by BGF Industries, Inc. (Greensboro, North Carolina) was selected for this application. The product is BGF's style #7721, flame resistant finish 972B, capable of withstanding temperatures up to 1100°F. Note that the BGF product must be keep at least 2 feet of more away from the burner flame. This material is also used as the curtain wall to segregate large target areas into 1300 ft^2 incremental areas.

An alternative high temperature fabric is the Siltemp silica fabric manufactured by the AMETEK Chemical Products Division (Marshallton, Delaware), which has a temperature limit of 2000°F. This product is useful if thermal blanket is needed in the immediate area of the burner flame.

3.8.3 Insulation and Flexible Connectors

Several vendors manufacture insulation for use in the target area for applications such as insulating the building materials from the 2000°F recirculating burner, or insulating galvanized steel or other materials from the heat. Insulation can be procured locally by specifying the required R factor and thickness as determined by calculating the heat losses. Insulation manufacturers have proprietary computer programs for the calculation of heat losses and the determination of insulation thickness.

BGF Industries, Inc. can furnish the BGF mat which is a mechanically bonded glass fiber insulating blanket of uniform density that provides reliable, superior performance at temperatures up to 1200°F. Owens Corning (Toledo, Ohio) manufactures a variety of building products including residential and commercial insulation. Their product line includes boards, blankets, batts and loose fill insulation. The product line is available countrywide and pricing is very competitive. Johns Manville (Denver, Colorado) is a major manufacturer of insulation products including board, blanket, or batt. Spin-Glas HTB 26 or HTB 23 are suitable products for HGD applications.

U-Nova (West Berlin, New Jersey) is a manufacturer of flexible, high temperature hose. This product is specified for use as the hot air supply duct from the air heater to the target area. It is available in sizes up to 24 in diameter and can withstand temperatures from -200°F to +1,000°F. The length of the duct used should be minimized because of the low static pressure developed by the air heater supply fan. U-Nova products are well suited for flexible tubing needs.

3.8.4 Thermal Oxidizers

Option 1 HGD with Off-Gas Treatment requires a thermal oxidizer to destroy off-gas constituents. Components of the thermal oxidizer include the combustion air fan, inlet chamber, main burner, pilot burner, fume piping, auxiliary fuel piping, combustion chamber controls, instrumentation/controls, and exhaust stack.

Standard, off-the-shelf thermal oxidizers available for lease have a maximum operating temperature of 1400°F with a residence time of one-half second. These units are relatively inexpensive, but do not meet the design criteria of 1800°F with a residence time of two seconds. The removal efficiencies of the lower temperature units (1400°F/0.5 seconds) for removing volatilized explosives contamination from off-gas have never been demonstrated. Vendor information on these thermal oxidizers is presented here since they are standard-of-industry equipment, on the possibility that they may be approved for use at a location. The higher operating temperatures and longer residence times (1800°F at 2 seconds as required by the design criteria for Option 1) are custom design and fabrication, and more expensive.

The vendor product selected as optimal for price and performance at the model facility is manufactured by MEGTEK Industries (DePere, Wisconsin) (formerly E Products, Inc.). MEGTEK offers a thermal oxidizer custom built to operate at 1800°F with a 2 second residence time, to meet the HGD design criteria. A 500 cubic feet per minute (cfm) unit is available for purchase or lease. Delivery of the unit is usually within 12 to 18 weeks. MEGTEK also offers a standard thermal oxidizer operating at 1400°F with a 0.5 second residence time.

As an alternative, Alzeta Corporation manufactures the EDGE QR flameless thermal oxidation system which is designed to maximize destruction efficiencies while minimizing operating costs. The EDGE QR burner is an inward-fired ceramic fiber radiant burner. The inward-fired burner walls form a nearly adiabatic chamber that allows combustion to be stabilized in a pre-mixed fuel-oxidizer stream at a very high level of excess combustion air. The thermal oxidizer operates at approximately 1500 to 1800°F without any visible flames and an uniform release of heat over its entire surface. At a residence time of less than 2 seconds, the unit has a demonstrated destruction efficiency of 99.9999% with essentially no NO, CO, or other incomplete combustion products in the exhaust.

SECTION 4

BASELINE COST AND SCHEDULE ESTIMATES

4.1 PRELIMINARY COST ESTIMATE

4.1.1 Baseline HGD System (No Off-Gas Treatment) at the Model Facility

A preliminary cost estimate has been developed for the Baseline HGD system (No Off-Gas Treatment) applied at the model facility. The cost for labor, equipment, materials, and supplies to design, procure, construct, operate, and decommission the Baseline HGD system are included. The cost information is based on using locally available materials and rental or leasing of equipment. A cost estimate for non-explosives type environmental problems (pigeon droppings, asbestos removal, lead based paint, and the like) is not included and must be prepared on a case-by-case basis. A cost for site characterization including sampling and analysis is not included, nor is the cost of post-HGD sampling and analysis. Detailed cost information for the baseline HGD system is presented in Table 4-1 broken down into project elements by labor, materials, and equipment costs. Vendor budgetary quotes were obtained for equipment used in the cost estimate and are presented in Appendix C.

The cost for the Baseline HGD system without Off-Gas Treatment in 1998 dollars is $223,000, or approximately $172 per ft^2, to decontaminate a 1300 ft^2 contaminated building (or room) containing contaminated equipment. The HGD system can be reused at an adjacent area for a large cost reduction due to economy of size. The cost for additional adjacent square footage at the same location is about $19 per ft^2. For a 4400 ft^2 model building selected as an example, the building can be decontaminated using HGD technology for $295,000 or approximately $67 per ft^2.

TABLE 4-1
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
BASELINE HGD SYSTEM WITHOUT OFF-GAS TREATMENT
COST SUMMARY

ITEM	COST
Design/Administration (labor and other direct costs)	$44,000
Capital Cost	$57,000
Leased Equipment (lease and labor)	$8,000
Construction (w/Profit &Overhead, and contingency)	$81,000
Operation (labor and fuel)	$28,000
Decommissioning (labor only)	$4,800
Total Cost for HGD of 1300 ft^2 Facility	$223,000
Cost per Square Foot for Initial 1300 ft^2	$172
Added Cost Per Each Additional 1300 ft^2	$24,000
Total Cost For Model Facility @ 4400 ft^2	$295,000
Cost per Square Foot for 4400 ft^2 Model Facility	$67

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT
COST BREAKDOWN FOR INITIAL 1300 SQ. FT.

ITEM/TASK DESCRIPTION	COST
Engineering & Administration	$43,994
Site Work, Start-up, Operation, & Decomissioning	$32,000
Leased Equipment, Installed Cost	$6,400
Fuel	$22,314
Mechanical Equipment, Installed Cost	$41,718
Instrumentation & Controls, Installed Cost	$23,463
Electrical Equipment, Installed Cost	$6,372
Subtotals	$176,261
Subcontractor Profit &Overhead @ 15% of labor and material	$26,439
Contingency @ 10%	$20,270
Cost for HGD of initial 1300 ft^2 area	**$223,005**

List of abbreviations:
EA = Each
ft^2 = Square Foot
gal = gallons
hp = horsepower
hr = hour
KVA = Kilovolt Amps
LS = Lump Sum
LF = Linear Foot
MH = Manhour

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Engineering & Administration									
100	**Design Package**									
100.01	Drawings, 8 @ 40 MH	320	MH	$70.00	$22,400					$22,400
100.02	Specifications, 13 @ 6 MH	78	MH	$70.00	$5,460					$5,460
100.03	Production costs, 4 issues	1	LS	$900.00	$900					$900
200	**Procurement**									
200.01	Bid advertisement	24	MH	$50.00	$1,200			$250.00	$250	$1,450
200.02	Bid review and contract award	48	MH	$50.00	$2,400					$2,400
200.03	Equipment purchase and submittals	48	MH	$50.00	$2,400					$2,400
300	**Health and Safety Plan**									
300.01	Senior Engineer	24	HR	$90.00	$2,160					$2,160
300.02	Technical Support	16	HR	$37.00	$592					$592
400	**Project Quality Assurance Plan**									
400.01	Senior Engineer	24	HR	$90.00	$2,160					$2,160
400.02	Engineer	32	HR	$65.00	$2,080					$2,080
500	**Closure report**									
500.01	Engineer	24	HR	$65.00	$1,560					$1,560
500.02	Support Staff	16	HR	$27.00	$432					$432
	SUBTOTALS THIS PAGE									$43,994

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Construction									
600	**Site Work**									
600.01	Mobilization w/phone	1	LS		$4,300					$4,300
600.02	Demobilization	1	LS		$6,500					$6,500
600.03	Trailer Rental	2	MO			$180.00	$360			$360
600.04	Delivery	1	LS	$200.00	$200					$200
600.05	Block & tiedown	1	LS	$220.00	$220					$220
600.06	Return delivery	1	LS	$200.00	$200					$200
600.07	Unblock & untiedown	1	LS	$180.00	$180					$180
600.10	**Field Testing and Startup**									
600.11	Senior Engineer	32	HR	$90.00	$2,880					$2,880
600.12	Engineer	24	HR	$65.00	$1,560					$1,560
600.13	Mechanic/Fitter	40	HR	$60.00	$2,400					$2,400
600.14	Operator	60	HR	$60.00	$3,600					$3,600
600.20	**Operation**									
600.21	Mechanic	80	HR	$60.00	$4,800					$4,800
600.22	Operator	80	HR	$60.00	$4,800					$4,800
600.30	**Decommissioning**									
600.31	Mechanic	80	HR	$60.00	$4,800					$4,800
	SUBTOTALS THIS PAGE									$32,000

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Leased Equipment									
700	**Leased Equipment, Installed Cost**									
700.01	Generator, portable, 10 KVA, 120/240,									
	1 phase, trailer mounted	2	MO			$1,400.00	$2,800			$2,800
700.02	2000 gal Convault fuel tank (generator)	2	MO			$600.00	$1,200			$1,200
	w/stairs, base, and pump									
700.03	Installation Labor (2 workers @ 2 days)	32	HR	$50.00	$1,600					$1,600
700.04	Dismantling Labor (2 workers@ 1 day)	16	HR	$50.00	$800					$800
	Total									$6,400
800	**Fuel**									
800.01	#2 Diesel fuel for generator, using									
	4 gal. per hour @ 60 x 24 hr days	5760	GAL					$1.40	$8,064	$8,064
800.02	Propane fuel for heaters, using 26 gal									
	per hr @ 60 x 24 hr days	38000	GAL					$0.375	$14,250	$14,250
	Total									$22,314
	SUBTOTALS THIS PAGE									$28,714

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total Cost
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	
	Mechanical Equipment, Installed									
900	**Gas Supply**									
900.01	1-1/2" Schedule 40, carbon steel pipe	100	LF	$5.55	$555			$3.25	$325	$880
900.02	1-1/2" 90° elbows, carbon steel	6	EA	$33.55	$201			$11.17	$67	$268
900.03	1-1/2" Ball valve, carbon steel	2	EA	$18.90	$38			$27.50	$55	$93
1000	**Building Materials**									
1000.01	Flame resistant blanket	1800	SF	$0.75	$1,350			$0.40	$720	$2,070
1000.02	Install steel base for blanket	1	LS		$1,000				$300	$1,300
1000.03	Sheet steel @ base for blanket	1300	SF	$0.50	$650			$1.00	$1,300	$1,950
1100	**Stack**									
1100.01	20" dia. x 20' tall x #20 gage @ 5' secti	4	EA	$50.00	$200			$93.00	$372	$572
1100.02	20" x 45° el	1	EA	$20.00	$20			$60.00	$60	$80
1100.03	20" wye section	1	EA	$30.00	$30			$75.00	$75	$105
1100.04	20" base flange	1	EA	$20.00	$20			$30.00	$30	$50
1100.05	20" flex x 24"	1	EA	$50.00	$50			$100.00	$100	$150
1100.06	20" diameter section clamps w/ seals	8	EA	$10.00	$80			$12.00	$96	$176.00
1100.07	Guy wires w/ turnbuckles	3	LS		$100			$200.00	$200	$300.00
1200	**Air Heaters**									
1200.01	Hauck SVG high velocity recirculating									
	burner assembly w/ gas train	2	EA	24mh@$6	$2,880			$15,422	$30,844	$33,724
	SUBTOTALS THIS PAGE									$41,718

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
1300	**Instrumentation and Controls**									
1300.01	Thermocouples w/ 125' of lead wire	12	LS		$1,200				$1,563	$2,763
1300.02	Data Aquisition System	1	LS		$1,200				$3,500	$4,700
1300.03	Programming	1	LS		$12,000					$12,000
1300.04	Set-up and test	1	LS		$4,000					$4,000
	SUBTOTALS THIS PAGE									$23,463

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
1400	**Electrical Equipment, Installed**									
1400.01	Generator conductors	1	100 LF		$310				$885	$1,195
1400.02	Supply air fan conductors	2	100 LF	$190.00	$380			$465.00	$910	$1,290
1400.03	Other branch circuit conductors	10	100LF	$29.00	$290			$62.00	$620	$910
1400.04	Distribution Panel	1	each		$560				$1,160	$1,720
1400.05	Ground rod	1	each		$44				$16	$60
1400.06	Motor Starter rated for 15 hp	2	each	$107.00	$215			$160.00	$320	$535
1400.07	Toggle Switch	1	each		$35				$44	$79
1400.08	Receptacle	3	each	$34.00	$102			$51.00	$153	$255
1400.09	Steel Channel for equipment monitoring	8	each	$24.00	$192			$17.00	$136	$328
	SUBTOTALS THIS PAGE									$6,372

TABLE 4-1 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR BASELINE SYSTEM WITHOUT OFF GAS TREATMENT
FOR EACH ADDITIONAL 1300 SQ. FT.

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Additional 1300 ft^2 (each)									
600.10	**Field Testing and Startup**									
600.11	Senior Engineer	8	HR	$90.00	$720					$720
600.12	Engineer	8	HR	$65.00	$520					$520
600.13	Mechanic/Fitter	16	HR	$60.00	$960					$960
600.14	Operator	24	HR	$60.00	$1,440					$1,440
600.20	**Operation**									
600.21	Operator	40	HR	$60.00	$2,400					$2,400
600.30	**Decommissioning**									
600.31	Mechanic	24	HR	$60.00	$1,440					$1,440
700	**Leased & Process Equipment**									
700.01	Generator, portable, 75 KVA, 120/208,	1	MO			$3,000.00	$3,000			$3,000
	3 phase, trailer mounted									
700.02	2000 gal Convault fuel tank	1	MO			$600.00	$600			$600
800	**Fuel**									
800.01	#2 Diesel fuel for generator, using									
	2 gal. per hour @10 x 24 hr days	960	GAL					$1.40	$1,344	$1,344
800.02	Propane fuel for heaters, using 26 gal.									
	per hr. @ 10 x 24 hr days	6240	GAL					$0.375	$2,340	$2,340
900	**Gas Supply**									
900.01	Relocate burners and piping	1	LS	$250.00						$250
1000	**Building Materials**									
1000.01	Flame resistant blanket (additional)	600	SF	$0.75	$450			$0.40	$242.40	$692
1000.02	Relocate existing blanket	1300	LS		$650					$650
1300	**Instrumentation and Controls**									
1300.01	Thermocouples w/ 125' of lead wire	12	LS		$1,200				$1,563	$2,763
	TOTALS									$19,119
	Subcontractor, Profit & Overhead@15%									2867.91
	Subtotal with Profit and Overhead									$21,987
	Contingency @ 10%									$2,199
	SUBTOTALS THIS PAGE									$24,186

4.1.2 Option 1 - HGD System with Off-Gas Treatment at the Model Facility

Similarly, a preliminary cost estimate has been developed for the Option 1 - HGD system (with Off-Gas Treatment) applied at the model facility. The cost for labor, equipment, materials, and supplies to design, procure, construct, operate, and decommission the Option 1 HGD system are included. Detailed cost information for the Option 1 HGD system is presented in Table 4-2 broken down into project elements by labor, materials, and equipment costs. Vendor budgetary quotes were obtained for equipment used in the cost estimate and are presented in Appendix C.

Similarly, the cost for the Option 1 - HGD system with the Off-Gas Treatment in 1998 dollars is $294,000, or about $226 per ft^2, to decontaminate a 1300 ft^2 contaminated building (or room) containing contaminated equipment. Again, the system can be reused at an adjacent area for a large cost reduction. The cost for additional adjacent square footage at the same location is about $25 per ft^2. The 4400 ft^2 model building can be decontaminated using HGD technology for $393,000 or approximately $89 per ft^2.

TABLE 4-2
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF-GAS TREATMENT
COST SUMMARY

ITEM	COST
Design/Administration (labor and other direct costs)	$44,000
Capital Cost	$55,000
Leased Equipment (lease and labor)	$43,000
Construction (w/Profit &Overhead, and contingency)	$102,000
Operation (labor and fuel)	$39,000
Decommissioning (labor only)	$4,800
Total Cost for HGD of 1300 ft^2 Facility	$294,000
Cost per Square Foot for Initial 1300 ft^2	$226
Added Cost Per Each Additional 1300 ft^2	$33,000
Total Cost For Model Facility @ 4400 ft^2	$393,000
Cost per Square Foot for 4400 ft^2 Model Facility	$89

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - SYSTEM WITH OFF GAS TREATMENT
COST BREAKDOWN for INITIAL 1300 SQ. FT.

Item/Task Description		Task Cost
Engineering & Administration		$43,994
Site Work, Start-up, Operation, & Decommissioning		$36,800
Leased Equipment, Installed Cost		$48,350
Fuel		$33,564
Mechanical Equipment, Installed Cost		$40,285
Instrumentation & Controls, Installed Cost		$23,463
Electrical Equipment, Installed Cost		$6,372
Subtotals		$198,936
Subcontractor Profit &Overhead @ 15% of labor and material		$29,730
Contingency @ 10%		$22,727
Total Cost		**$294,000**

List of abbreviations:
EA = Each
ft^2 = Square Foot
gal = gallons
hp = horsepower
hr = hour
KVA = Kilovolt Amps
LS = Lump Sum
LF = Linear Foot
MH = Manhour
MO = Month
TO = Thermal Oxidizer

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Engineering & Administration									
100	**Design Package**									
100.01	Drawings, 8 @ 40 MH	320	MH	$70.00	$22,400					$22,400
100.02	Specifications, 13 @ 6 MH	78	MH	$70.00	$5,460					$5,460
100.03	Production costs, 4 issues	1	LS	$900.00	$900					$900
200	**Procurement**									
200.01	Bid advertisement	24	MH	$50.00	$1,200			$250.00	$250	$1,450
200.02	Bid review and contract award	48	MH	$50.00	$2,400					$2,400
200.03	Equipment purchase and submittals	48	MH	$50.00	$2,400					$2,400
300	**Health and Safety Plan**									
300.01	Senior Engineer	24	HR	$90.00	$2,160					$2,160
300.02	Technical Support	16	HR	$37.00	$592					$592
400	**Project Quality Assurance Plan**									
400.01	Senior Engineer	24	HR	$90.00	$2,160					$2,160
400.02	Engineer	32	HR	$65.00	$2,080					$2,080
500	**Closure report**									
500.02	Engineer	24	HR	$65.00	$1,560					$1,560
500.03	Support Staff	16	HR	$27.00	$432					$432
	SUBTOTALS THIS PAGE									$43,994

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	General Requirements									
600	**Site Work**									
600.01	Mobilization w/ phone	1	LS		$4,300					$4,300
600.02	Demobilization	1	LS		$6,500					$6,500
600.03	Trailer Rental	2	MO			$180.00	$360			$360
600.04	Delivery	1	LS	$200.00	$200					$200
600.05	Block & tiedown	1	LS	$220.00	$220					$220
600.06	Return delivery	1	LS	$200.00	$200					$200
600.07	Unblock & untiedown	1	LS	$180.00	$180					$180
600.10	**Field Testing and Startup**									
600.11	Senior Engineer	32	HR	$90.00	$2,880					$2,880
600.12	Engineer	24	HR	$65.00	$1,560					$1,560
600.13	Mechanic/Fitter	40	HR	$60.00	$2,400					$2,400
600.14	Operator	60	HR	$60.00	$3,600					$3,600
									$22,400	
600.20	**Operation**									
600.21	Mechanic	80	HR	$60.00	$4,800					$4,800
600.22	Operator	80	HR	$60.00	$4,800					$4,800
600.30	**Decomissioning**									
600.31	Mechanic	80	HR	$60.00	$4,800					$4,800
	SUBTOTALS THIS PAGE									$36,800

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1- SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total Cost
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	
	Leased Equipment & Fuel									
700	**Leased Equipment, Installed**									
700.01	Generator, portable, 10 KVA, 120/240,									
	1 phase, trailer mounted	2	MO			$1,400.00	$2,800			$2,800
700.02	2000 gal Convault fuel tank (generator)	2	MO			$600.00	$1,200			$1,200
	w/ stairs, base, and pump									
700.03	Installation Labor (2 workers @ 2 days)	32	HR	$50.00	$1,600					$1,600
700.04	Dismantling Labor (2 workers@ 1 day)	16	HR	$50.00	$800					$800
700.05	Thermal Oxidizer (1800°F @ 2 sec.)	5	MO			$6,990.00	$34,950			$34,950
	Installation Labor (2 workers @ 2 days)	80	HR	$50.00	$4,000					$4,000
	Dismantling Labor (2 workers@ 2 day)	60	HR	$50.00	$3,000					$3,000
	TOTAL									$48,350
800	**Fuel**									
800.01	#2 Diesel fuel for generator, using									
	4 gal. per hour @ 60 x 24 hr days	5760	GAL					$1.40	$8,064	$8,064
800.02	Propane fuel for Thermal Oxidizer									
	60 days @ 500 gal. per day	30000	GAL					$0.375	$11,250	$11,250
800.03	Propane fuel for heaters, using 26 gal									
	per hr @ 60 x 24 hr days	38000	GAL					$0.375	$14,250	$14,250
	TOTAL									$33,564
	SUBTOTALS THIS PAGE									$81,914

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total Cost
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	
	Mechanical									
900	**Gas Supply**									
900.01	1-1/2" Schedule 40, carbon steel pipe	100	LF	$5.55	$555			$3.25	$325	$880
900.02	1-1/2" 90 elbows, carbon steel	6	EA	$33.55	$201			$11.17	$67	$268
900.03	1-1/2" Ball valve, carbon steel	2	EA	$18.90	$38			$27.50	$55	$93
1000	**Building Materials**									
1000.01	Flame resistant blanket	1800	SF	$0.75	$1,350			$0.40	$720	$2,070
1000.02	Install steel base for blanket	1	LS		$1,000				$300	$1,300
1000.03	Sheet steel @ base for blanket	1300	SF	$0.50	$650			$1.00	$1,300	$1,950
1100	**Stack**									
	Furnished with Thermal Oxidizer Assembly									
1200	**Air Heaters**									
1200.01	Hauck SVG high velocity recirculation									
	burner assembly with gas train	2	EA	24mh@$6	$2,880			$15,422	$30,844	$33,724
	SUBTOTALS THIS PAGE									$40,285

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total Cost
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	
1300	**Instrumentation and Controls**									
1300.01	Thermocouples w/ 125 ft. of lead wire	12	LS		$1,200				$1,563	$2,763
1300.02	Data Aquisition System	1	LS		$1,200				$3,500	$4,700
1300.03	Programming	1	LS		$12,000					$12,000
1300.04	Set-up and test	1	LS		$4,000					$4,000
	SUBTOTALS THIS PAGE									$23,463

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE
OPTION 1 - HGD SYSTEM WITH OFF GAS TREATMENT

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
1400	**Electrical**									
1400.01	Generator conductors	1	100 LF		$310				$885	$1,195
1400.02	Supply air fan conductors	2	100 LF	$190.00	$380			$465.00	$910	$1,290
1400.03	Other branch circuit conductors	10	100LF	$29.00	$290			$62.00	$620	$910
1400.04	Distribution Panel	1	each		$560				$1,160	$1,720
1400.05	Ground rod	1	each		$44				$16	$60
1400.06	Motor Starter rated for 15 hp	2	each	$107.00	$215			$160.00	$320	$535
1400.07	Toggle Switch	1	each		$35				$44	$79
1400.08	Receptacle	3	each	$34.00	$102			$51.00	$153	$255
1400.09	Steel Channel for equipment monitoring	8	each	$24.00	$192			$17.00	$136	$328
	SUBTOTALS THIS PAGE									$6,372

TABLE 4-2 (continued)
LOW COST DISPOSABLE HOT GAS DECONTAMINATION SYSTEM
PRELIMINARY COST ESTIMATE FOR SYSTEM WITH OFF GAS TREATMENT
FOR EACH ADDITIONAL 1300 SQ. FT.

Item No.	Item/Task Description	Quantity		Labor		Equipment		Material		Total
		# Units	Unit	Unit Price	Cost	Unit Price	Cost	Unit Price	Cost	Cost
	Additional 1300 ft^2 (each)									
600.10	**Field Testing and Startup**									
600.11	Senior Engineer	8	HR	$90.00	$720					$720
600.12	Engineer	8	HR	$65.00	$520					$520
600.13	Mechanic/Fitter	16	HR	$60.00	$960					$960
600.14	Operator	24	HR	$60.00	$1,440					$1,440
600.20	**Operation**									
600.21	Operator	40	HR	$60.00	$2,400					$2,400
600.31	Mechanic	24	HR	$60.00	$1,440					$1,440
700	**Leased & Process Equipment**									
700.01	Generator, portable, 10 KVA, 120/240,	1	MO			$1,400.00	$1,400			$1,400
	1 phase, trailer mounted									
700.02	2000 gal Convault fuel tank	1	MO			$600.00	$600			$600
700.05	Thermal Oxidizer (1800°F @ 2 sec.)	1	MO			$6,990.00	$6,990			$6,990
800	**Fuel**									
800.01	#2 Diesel fuel for generator, using									
	4 gal. per hour @ 8 x 24 hr days	768	GAL					$1.40	$1,075	$1,075
800.02	Propane for heaters, 26 gal./hr@192 hr	4992	GAL					$0.375	$1,872	$1,872
800.03	Propane fuel for TO, 500 gal @ 8 days	4500	GAL					$0.375	$1,688	$1,688
900	**Gas Supply**									
900.01	Relocate burners and piping	1	LS	$250.00						$250
900.02	Relocate TO piping and duct	1	LS	$750.00						$750
1000	**Building Materials**									
1000.01	Flame resistant blanket (additional)	600	SF	$0.75	$450			$0.40	$242.40	$692
1000.02	Relocate existing blanket	1300	LS		$650					$650
1300	**Instrumentation and Controls**									
1300.01	Thermocouples w/ 125 ft. of lead wire	12	LS		$1,200				$1,563	$2,763
	TOTALS									$26,210
	Subcontractor, Profit & Overhead @15%									$3,932
	Subtotal with Profit & Overhead									$30,142
	Contingency @ 10%									$3,014
	SUBTOTALS THIS PAGE									$33,156

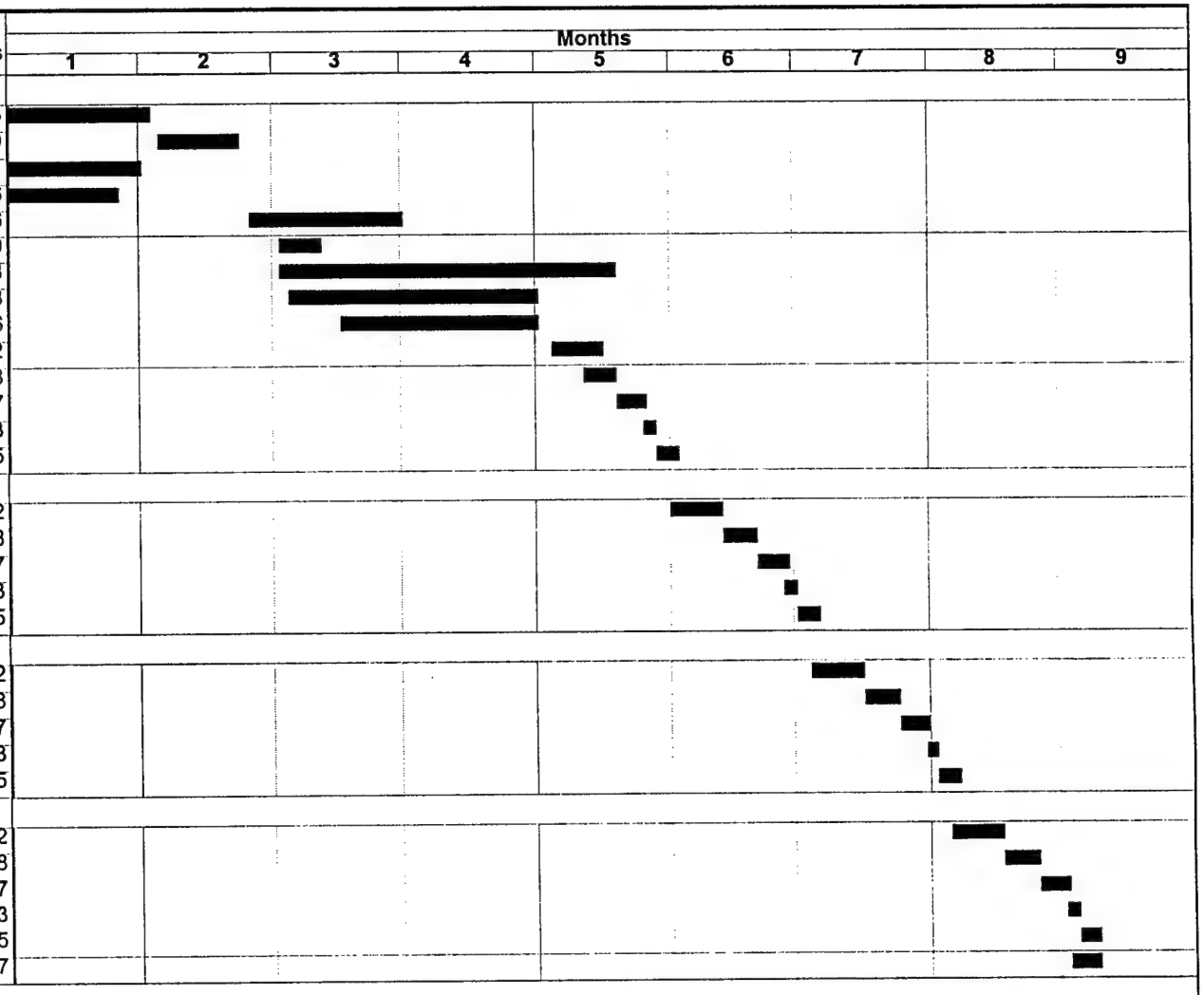
4.2 PROJECT SCHEDULE

A preliminary schedule for planning, design, construction, operation, and decommissioning of the HGD system is presented in Figure 4-1. The system would require approximately 5 months from inception to decontamination of the initial 1300 ft^2 target area. Each additional 1300 (or less) ft^2 area would take about 1 month to setup, operate, and take down the HGD system. For the 4400 ft^2 model facility, a total of about 8 months would be required to decontaminate the facility.

The schedule does not include decontamination and decommissioning activities not related to HGD such as:

- Site characterization prior to decontamination;
- Site preparation for other (non-explosives) environmental concerns prior to HGD; and
- Demolition of the building after HGD or cleanup for reuse.

Activity ID	Activity Description	Cal Days
AREA 1, 1,300 FT2		
10	PRELIMINARY DESIGN	33
20	FINAL DESIGN	19
30	HEALTH & SAFETY PLAN	31
40	QUALITY ASSURANCE PLAN	26
50	PROCUREMENT	36
60	CONSTRUCTION MOBILIZATION	10
70	CONSTRUCTION	78
80	EQUIPMENT DELIVERY	58
90	EQUIPMENT INSTALLATION	46
100	COMPONENT CHECKOUT & SYSTEMIZATION CHECK	12
110	SYSTEM ACCEPTANCE	8
130	OPERATION	7
140	FINAL SAMPLING/VERIFICATION	3
150	DECOMMISSIONING	5
AREA 2, 1,300 FT2		
170	EQUIPMENT INSTALLATION/CONSTRUCTION	12
190	SYSTEM ACCEPTANCE	8
210	OPERATION	7
220	FINAL SAMPLING/VERIFICATION	3
230	DECOMMISSIONING	5
AREA 3, <1,300 FT2		
250	EQUIPMENT INSTALLATION/CONSTRUCTION	12
260	SYSTEM ACCEPTANCE	8
270	OPERATION	7
280	FINAL SAMPLING/VERIFICATION	3
290	DECOMMISSIONING	5
AREA 4, <1,300 FT2		
310	EQUIPMENT INSTALLATION/CONSTRUCTION	12
320	SYSTEM ACCEPTANCE	8
330	OPERATION	7
340	FINAL SAMPLING/VERIFICATION	3
350	DECOMMISSIONING	5
360	CLOSURE REPORT	7



Run Date 17NOV98

Early Bar
Progress Bar

GAS1

Sheet 1 of 1

SCHEDULE FOR DECONTAMINATION
OF MODEL FACILITY
LOW COST HOT GAS DECONTAMINATION

SECTION 5

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APPENDIX A

CALCULATIONS

PARSONS

Calculation Sheet

Rev	By	Date	Ck	Date	Title
	EB	5/20/98			Low Cost Disposable Hot Gas Decontamination for Explosives Contaminated Equipment & Facilities
					Author E. Bondarewicz Sheet 1 Of 3

CALCULATION FOR SYSTEM HEAT LOSS @ WASHOUT BLDG.
ANALYZE HEAT LOAD FOR CONCRETE HEAT-UP
ASSUME 8" PENETRATION OF CONCRETE TO
DECONTAMINATE HAIR-LINE CRACKING

1.) GIVEN: 1200 ℄ OF SLAB @ 8" THICK
AMBIENT AIR TEMP @ 60°F
CONCRETE @ 140 #/FT³
SPECIFIC HEAT CONCRETE @ 0.22 BTU/#/°F
UMATILLA/HANFORD AREA FOR AMBIENT.
HEAT-UP TEMP = 600°F
Q = BTU/HR.

$Q = \text{WEIGHT, \#} \left(\text{SP. HEAT}\right)\left(\text{temp diff @ °F}\right)$

$= \frac{(1200)(8)}{1\text{FT}} \times 0.22 \times 540°\text{F} \times 140\#$

$= 13,305,600 \text{ BTU/HR.}$

TRY 6" THICK PENETRATION
∴ Q = 9,979,200 BTU/HR

NOTE: FOR TWO (2) HOUR HEAT-UP
VALUES CAN BE HALVED.
FOR LONGER PERIODS —
WALL & SURFACE LOSSES SHOULD
BE CALCULATED, HALVED, AND
USED AS AN AVERAGE VALUE
FOR A CONTINUOUS PERIOD
LASTING LONGER THAN 2 HOURS

PARSONS

Calculation Sheet

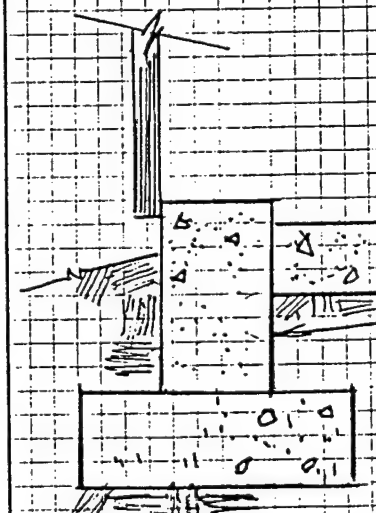
Rev	By	Date	Ck	Date	Title
	EB	5/21/98			LOW COST DISPOSABLE HOT GAS DECONTAMINATION for EXPLOSIVES CONTAMINATED EQUIPMENT & FACILITIES
					Author E. BONDARCHUK Sheet 2 Of 3

8" THICK HEAT-UP (CONCRETE) REQUIRES 13,305,600 BTU/HR FOR A 1 HR HEAT-UP, ASSUME TWO (2) EXTERNAL HEATERS @ 1,400,000 BTU/HR OUTPUT, DETERMINE TIME OF HEAT-UP:

$$\frac{13,305,600}{(1,400,000)(2)} = 4.75 \text{ HOURS}$$

SAY 5 HOURS FOR HEAT-UP ←

2) CALCULATE LOSS OF HEAT THRU REST OF CONCRETE SLAB, ASSUMED @ 12" THICK, AND LOSSES THROUGH WALL AND FOUNDATION WALL.



FROM ASHRAE FUNDAMENTALS 1993, TABLE 14

WALL LOSS = 0.410 BTU/HR·FT·°F

$= (0.410)(140)(540) = 31,000$ BTU/HR

FLOOR LOSS = 0.029 BTU/HR·FT²·°F

$= (0.029)(1144)(540) = 18,000$ BTU/HR

$\therefore \frac{31,000 + 18,000}{2} = 24,500$ BTU/HR AVG. LOSS

$\frac{13,305,600}{(4.75)(2)} + 24,500 = 1,425,089$ BTU/HR INPUT REQ'D @ FLOOR/WALL

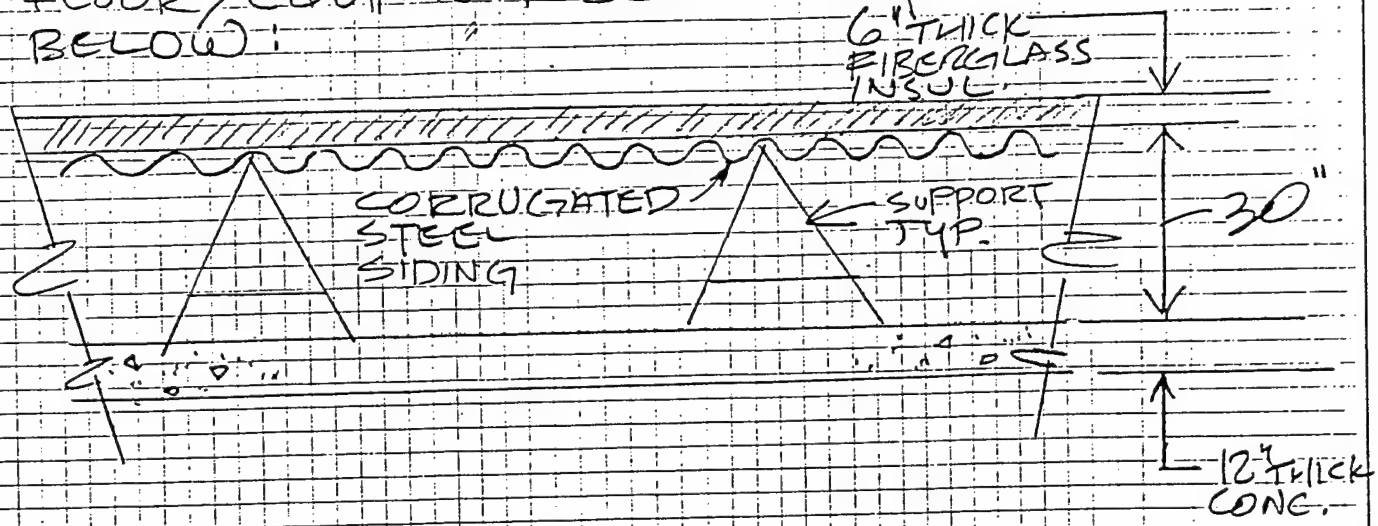
PARSONS

Calculation Sheet

Rev	By	Date	Ck	Date	Title
	ED	5/21/96			Low Cost Disposable Hot Gas Decontamination for Explosives Contaminated Equipment & Facilities
					Author

Sheet 3 Of 3

3.) Calculate loss of heat through floor/equipment decon. system shown below:



From Owens Corning physical property data:

6" insul @ insul-quick @ 650°F operating temp, heat loss = 44 BTU/HR · SQ FT.

∴ (44)(1144 ft²) = 50,336 BTU/HR loss

$\frac{50,336}{2}$ = 25,000 BTU/HR AVG. LOSS ←

Avg. losses compiled:

1. Fiberglass insul	= 25,000
2. Floor & wall	= 24,500
3. Heat-up @ conc.	= 1,425,000
← Total input/HR	= 1,474,500 BTU/HR

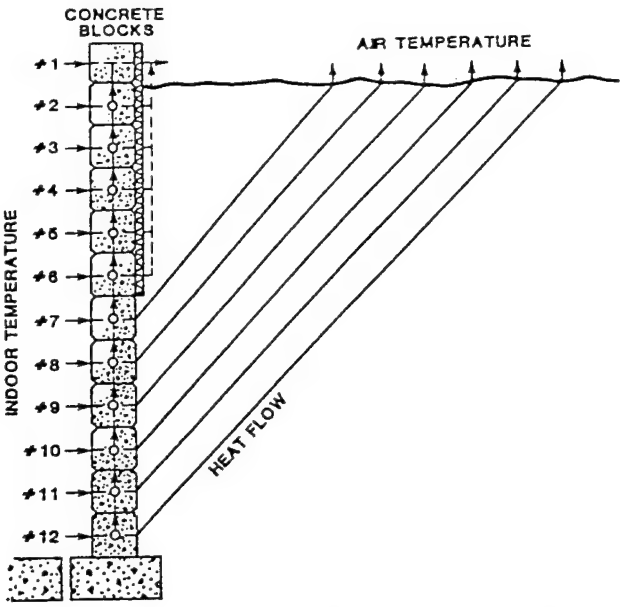


Fig. 5 Heat Flow Path for Partially Insulated Basement Wall

Once the heat paths are known or assumed, a steady-state analysis can calculate the overall heat transmission coefficient for each segment of the basement wall. Referring to Figures 4 and 5, the total thermal resistance for each depth increment of the basement wall can be found by summing the thermal resistances along each heat flow path. Based on these resistances, the heat loss at each depth increment can be estimated for a unit temperature difference between the basement and the average mean winter temperature. Table 14 lists such heat loss values at different depths for an uninsulated and an insulated concrete wall (Latta and Boileau 1969). Also listed are the lengths of the heat flow path through the soil (circular path).

Table 14 Heat Loss Below Grade in Basement Walls

Depth, ft	Path Length Through Soil, ft	Heat Loss Coefficient, Btu/h·ft²·°F[a]							
		Uninsulated		R-4.17		R-8.34		R-12.5	
0 to 1	0.68	0.410	Σ[b]	0.152	Σ[b]	0.093	Σ[b]	0.067	Σ[b]
1 to 2	2.27	0.222	0.632	0.116	0.268	0.079	0.172	0.059	0.126
2 to 3	3.88	0.155	0.787	0.094	0.362	0.068	0.240	0.053	0.179
3 to 4	5.52	0.119	0.906	0.079	0.441	0.060	0.300	0.048	0.227
4 to 5	7.05	0.096	1.002	0.069	0.510	0.053	0.353	0.044	0.271
5 to 6	8.65	0.079	1.081	0.060	0.570	0.048	0.401	0.040	0.311
6 to 7	10.28	0.069	1.150	0.054	0.624	0.044	0.445	0.037	0.348

Source: Latta and Boileau (1969).
[a]Soil conductivity was assumed to be 9.6 Btu·in/h·ft²·°F.
[b]Σ = heat loss to current depth.

Table 15 Heat Loss Through Basement Floors

Depth of Foundation Wall below Grade, ft	Heat Loss Coefficient, Btu/h·ft²·°F			
	Shortest Width of House, ft			
	20	24	28	32
5	0.032	0.029	0.026	0.023
6	0.030	0.027	0.025	0.022
7	0.029	0.026	0.023	0.021

Note: $\Delta t = (t_a - A)$

Through Basement Floors

The same steady-state design used for the basement wall can be applied to the basement floor, except that the length of the heat flow path is longer (see Figure 4). Thus, the heat loss through the

ASHRAE FUNDAMENTALS, 1995.

Table 1 Typical Densities, Thermal Diffusivities, and Specific Heats of Common Building Materials

Description	Density, lb/ft^3	Thermal Diffusivity, ft^2/h	Specific Heat, Btu/lb·°F
Concrete	140	0.27-0.054	0.22
Steel	484	0.038	0.12
Wood	22 to 44	0.005 to 0.006	0.40
Insulation	0.6 to 2.0	0.22 to 0.027]	0.2 to 0.38

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Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	2.5%	5%	Cldst Month WS/MDB 0.4% WS	0.4% MDB	1% WS	1% MDB	MWS/MWD to DB 99.6% MWS	99.6% MWD	0.4% MWS	0.4% MWD	Annual Extr. Daily Mean DB Max.	Mean DB Min.	StdD DB Max.	StdD DB Min.
Sterling	724030	38.95	77.45	322	14.525	6193	9	14	22	19	16	25	32	21	31	7	340	10	250	97	-1	3.3	7.0
Washington, National A	724050	38.85	77.03	66	14.661	8293	15	20	23	20	18	24	34	21	35	11	340	11	170	99	8	2.5	6.8
WASHINGTON																							
Bellingham	727976	48.80	122.53	157	14.612	8293	15	21	23	20	18	28	33	23	34	17	40	9	290	87	11	3.1	7.4
Hanford	727840	46.57	119.60	732	14.311	8293	5	12	25	21	18	24	44	19	44	6	20	8	20	105	2	3.1	9.0
Olympia	727920	46.97	122.90	200	14.589	6193	18	23	21	18	16	21	45	19	45	5	180	8	50	94	10	4.0	8.1
Quillayute	727970	47.95	124.55	203	14.588	6193	23	27	33	27	21	41	45	35	45	7	60	9	240	87	19	8.4	6.4
Seattle, Int'l Airport	727930	47.45	122.30	449	14.458	6193	23	28	22	19	17	24	44	21	44	10	10	10	350	92	19	3.6	6.8
Spokane, Fairchild AFB	727855	47.62	117.65	2461	13.435	6193	1	7	27	23	20	28	39	25	38	7	50	9	240	98	-7	3.2	8.7
Stampede Pass	727815	47.28	121.33	3967	12.708	8293	3	10	21	19	16	27	19	22	25	13	90	7	100	84	2	3.2	7.2
Tacoma, McChord AFB	742060	47.13	122.48	322	14.525	8293	18	24	18	15	13	22	45	18	46	2	180	7	20	94	12	2.7	6.8
Walla Walla	727846	46.10	118.28	1204	14.067	8293	4	12	22	19	17	24	49	22	47	6	180	9	300	105	1	3.2	11.7
Wenatchee	727825	47.40	120.20	1243	14.047	8293	3	9	22	19	17	17	36	12	31	3	100	9	280	101	-2	2.5	7.2
Yakima	727810	46.57	120.53	1066	14.138	6193	4	11	24	20	17	23	47	19	43	7	250	7	90	101	-2	3.2	8.5
WEST VIRGINIA																							
Bluefield	724125	37.30	81.20	2858	13.240	8293	5	12	15	13	12	18	34	15	33	6	270	6	290	88	-6	4.0	8.5
Charleston	724140	38.37	81.60	981	14.182	6193	6	11	18	16	14	20	38	18	34	7	250	8	240	94	-2	2.8	6.7
Elkins	724170	38.88	79.85	1998	13.665	6193	-2	5	20	18	16	22	30	19	30	4	280	8	290	88	-12	2.8	5.4
Huntington	724250	38.37	82.55	837	14.257	6193	6	11	19	16	14	20	32	17	32	8	270	8	270	94	-2	5.0	7.6
Martinsburg	724177	39.40	77.98	558	14.402	8293	8	14	21	18	16	23	33	20	34	7	270	9	290	99	-3	4.0	8.3
Morgantown	724176	39.65	79.92	1247	14.045	8293	4	11	18	15	13	19	32	17	33	6	210	8	240	93	-4	3.6	8.6
Parkersburg	724273	39.35	81.43	860	14.245	8293	4	11	18	16	14	20	32	18	29	7	240	8	270	95	-4	3.1	9.2
WISCONSIN																							
Eau Claire	726435	44.87	91.48	906	14.221	6193	-18	-13	22	19	17	21	14	20	13	7	250	13	220	95	-25	3.2	5.7
Green Bay	726450	44.48	88.13	702	14.326	6193	-13	-8	25	22	20	25	19	22	18	10	270	12	200	93	-19	2.8	5.6
La Crosse	726430	43.87	91.25	663	14.347	6193	-14	-8	23	20	18	23	13	21	13	7	310	12	180	97	-21	3.2	6.2
Madison	726410	43.13	89.33	866	14.241	6193	-11	-6	24	21	19	25	16	22	17	8	300	12	230	94	-18	3.2	6.0
Milwaukee	726400	42.95	87.90	692	14.332	6193	-7	-2	28	24	22	28	19	24	20	13	290	15	220	95	-12	3.2	6.7
Wausau	726463	44.93	89.63	1201	14.069	8293	-15	-9	19	17	15	19	16	17	17	7	300	10	200	93	-22	3.1	4.7
WYOMING																							
Big Piney	726710	42.57	110.10	6969	11.353	8293	-22	-15	24	20	17	22	25	19	21	3	60	11	260	87	-33	2.7	8.5
Jasper	725690	42.92	106.47	5289	12.096	6193	-13	-5	34	30	27	35	35	32	32	9	260	13	240	97	-22	2.2	8.4
Cheyenne, Warren AFB	725640	41.15	104.82	6142	11.714	6193	-7	0	34	29	26	38	36	33	34	10	290	13	290	92	-15	2.2	7.5
Cody	726700	44.52	109.02	5095	12.184	8293	-14	-7	34	28	23	35	35	30	35	6	40	11	70	95	-20	4.1	9.4
Gillette	726650	44.35	105.53	4035	12.675	8293	-16	-7	28	25	22	30	34	27	33	8	260	11	140	101	-20	5.9	10.1
Lander	725760	42.82	108.73	5558	11.974	6193	-14	-7	23	19	16	25	38	19	37	3	120	10	270	95	-20	2.5	7.8
Rock Springs	725744	41.60	109.07	6759	11.444	6193	-9	-2	28	25	23	32	25	29	24	7	70	13	280	90	-17	2.0	8.0
Sheridan	726660	44.77	106.97	3967	12.708	6193	-14	-8	28	24	20	29	32	23	27	5	280	9	120	99	-22	3.0	6.4
Worland	726665	43.97	107.95	4245	12.577	8293	-22	-13	22	19	16	20	28	17	28	3	210	9	220	103	-30	2.2	10.4

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Through Ceiling and Roof

Transmission heat loss through top floor ceilings, attics, and roofs may be estimated by either of two methods:

1. Substitute in Equation (5) the ceiling area A, the indoor/outdoor temperature difference $(t_i - t_o)$, and the proper U-factor:

   Flat roofs. Use appropriate coefficients in Equation (3) if side walls extend appreciably above the ceiling or the floor below.

   Pitched roofs. Calculate the combined roof and ceiling coefficient as outlined in Chapter 24.

2. For *pitched roofs*, estimate the attic temperature (based on the indoor and outdoor design temperatures) using Equation (3), and substitute for t_o in Equation (5), obtaining the value of t_a, together with the ceiling area A and the ceiling U-factor. Attic temperatures do not need to be calculated for *flat roofs*, as the ceiling-roof heat loss can be determined as suggested in Method 1 above.

From the Basement

The basement interior is considered conditioned space if a minimum temperature of 10°F below indoor design air temperature is maintained over the heating season. In many instances, the house heating plant, water heater, and heating ducts are in the basement, so it remains at or above 50°F.

Heat transmission from the below-grade portion of the basement wall to the ambient air cannot be estimated by simple, one-dimensional heat conduction. In fact, field measurement of an uninsulated basement by Latta and Boileau (1969) showed that the isotherms near the wall are not parallel lines but closer to radial lines centered at the intersection of the grade line and the wall. Therefore, heat flow paths approximately follow a concentric circular pattern (Figure 4).

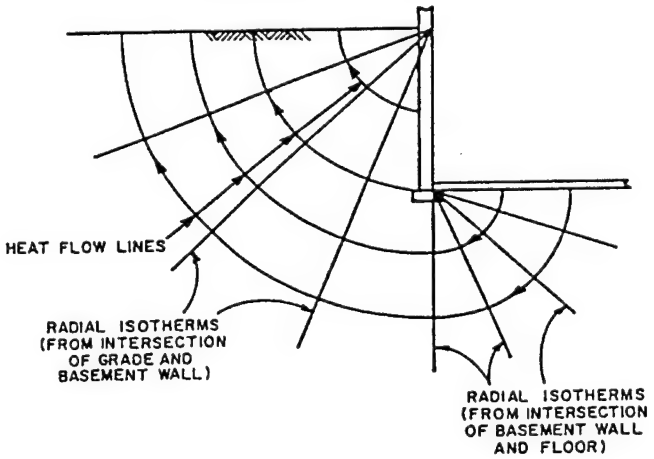

Fig. 4 Heat Flow from Basement

Such heat flow paths are altered when insulation is added to the wall or floor. An extreme case would be no heat loss from the basement wall and floor (i.e., infinite insulation applied to the wall and floor). In this case, the isotherms would be horizontal lines parallel to the grade line, and the heat flow would be vertical. When finite insulation or partial insulation is applied to the wall and floor, the heat flow paths take shapes somewhere between the circular and vertical lines (Figure 5).

Ground Temperature. Ground temperatures assumed for estimating basement heat losses will differ for basement floors and walls. The temperatures under floors are generally higher than those adjacent to walls. This is discussed further in the section on Basement Design Temperatures.

Through Basement Walls

Houghten et al. (1942) observed nonuniform heat flux across the basement wall with respect to the depth of the wall because each heat flow path contains a different thermal resistance. For a basement wall that has its top portion exposed to ambient air, heat may be conducted vertically through the concrete wall and dissipated to the ambient from the top portion of the wall (Wang 1979, Bligh et al. 1978). Under certain conditions, this vertical heat flux becomes significant and should not be ignored.

basement floor is much smaller than that through the wall. An average value for the heat loss through the basement floor can be multiplied by the floor area to give total heat loss from the floor. Table 15 lists typical values.

Basement Design Temperatures

Although internal design temperature is given by basement air temperature, none of the usual external design air temperatures apply because of the heat capacity of the soil. However, ground surface temperature fluctuates about a mean value by an amplitude A, which varies with geographic location and surface cover. Therefore, suitable external design temperatures can be obtained by subtracting A for the location from the mean winter air temperature t_a. Values for t_a can be obtained from meteorological records, and A can be estimated from the map in Figure 6. This map is part of one prepared by Chang (1958) giving annual ranges in ground temperature at a depth of 4 in.

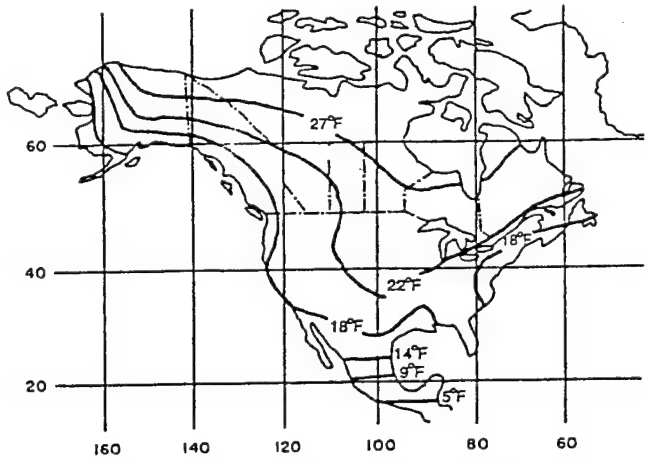

Fig. 6 Lines of Constant Amplitude

Example 6. Consider a basement 28 ft wide by 30 ft long sunk 6 ft below grade, with R-8.34 insulation applied to the top 2 ft of the wall below grade. Assume an internal air temperature of 70°F and an external design temperature ($t_a - A$) of 20°F.

Solution:

Wall (using Table 14)

First foot below grade	0.093 Btu/h·ft·°F
Second foot below grade	0.079 Btu/h·ft·°F
Third foot below grade	0.155 Btu/h·ft·°F
Fourth foot below grade	0.119 Btu/h·ft·°F
Fifth foot below grade	0.096 Btu/h·ft·°F
Sixth foot below grade	0.079 Btu/h·ft·°F
Total per foot length of wall	0.621 Btu/h·ft·°F
Basement perimeter	2(28+30) = 116 ft
Total wall heat loss	0.62 × 116 = 72 Btu/h·°F

Floor (using Table 15)

Average heat loss per ft²	0.025 Btu/h·ft²·°F
Floor area 28 × 30	840 ft²
Total floor heat loss	0.025 × 840 = 21 Btu/h·°F

Total

Total basement heat loss below grade	72 + 21 = 93 Btu/h·°F
Design temperature difference	70 − 20 = 50°F
Maximum rate of heat loss from below-grade basement	93 × 50 = 4650 Btu/h

If a basement is completely below grade and unheated, its temperature ranges between that in the rooms above and that of the ground. Basement windows lower the basement temperature when it is cold outdoors, and heat given off by the heating plant increases the basement temperature. The exact basement temperature is indeterminate if the basement is not heated. In general, heat from the heating plant

sufficiently warms the air near the basement ceiling to make unnecessary an allowance for floor heat loss from rooms located over the basement.

Transient Calculations for Basement Walls

The heat loss from basement walls can be estimated more accurately with a finite element or finite difference computer program by transient simulations (Wang 1979, Bligh et al. 1978). The solution is in the form of heat loss over time, which can be converted to an average U-factor. This approach also offers the possibility for estimating the depth below grade to which insulation is economical. Direct and indirect evidence of hollow concrete block walls shows that a convective path exists within the blocks vertically along the wall (Harrje et al. 1979). Therefore, insulation should be arranged to reduce this convective heat transfer.

Peony et al. (1979) showed that the dynamic thermal performance of a masonry wall is better when insulation is placed on the exterior. Moreover, transient simulation showed that insulation is more effective when it is placed on the exterior side of the basement wall. Depending on the exposed portion of the block wall and the temperature difference between indoor and outdoor air, exterior application can be 10 to 20% more efficient than a corresponding interior application. However, such exterior insulation must be installed properly to maintain its integrity.

Calculating Transmission Heat Loss from Floor Slabs

Concrete slab floors may be (1) unheated, relying for warmth on heat delivered above floor level by the heating system, or (2) heated, containing heated pipes or ducts that constitute a radiant slab or portion of it for complete or partial heating of the house.

The perimeter insulation of a slab-on-grade floor is quite important for comfort and energy conservation. In unheated slab floors, the floor edge must be insulated in order to keep the floor warm. Downdrafts from windows or exposed walls can create pools of chilly air over considerable areas of the floor. In heated slab floors, the floor edge must be insulated to prevent excessive heat loss from the heating pipe or duct embedded in the floor or from the baseboard heater.

Wang (1979) and Bligh et al. (1978) found that heat loss from an unheated concrete slab floor is mostly through the perimeter rather than through the floor and into the ground. Total heat loss is more nearly proportional to the length of the perimeter than to the area of the floor, and it can be estimated by the following equation for both unheated and heated slab floors:

$$q = F_2 P(t_i - t_o) \tag{6}$$

where

q = heat loss through perimeter, Btu/h
F_2 = heat loss coefficient per foot of perimeter (see Table 16), Btu/h·ft·°F
P = perimeter or exposed edge of floor, ft
t_i = indoor temperature, °F (For the heated slab, t_i is the weighted average heating duct or pipe temperature.)
t_o = outdoor temperature, °F

Vertical "I"-shaped systems are used to insulate slab floor perimeters. In the "I" system, the insulation is placed vertically next to the exposed slab edge, extending downward below grade, as shown in Figure 7.

Breaks or joints must be avoided when the insulation is installed; otherwise, local thermal bridges can be formed, and the overall efficiency of the insulation is reduced.

Transient Calculations for Floor Slabs

Figure 8 shows four basic slab-on-grade constructions analyzed with a finite element computer program by Wang (1979). Figures 8A-C represent unheated slabs; Figure 8D can be considered a heated slab. Each was investigated with and without insulation of R-5.4 under three climatic conditions (7433, 5350, and 2950 degree-days). Table 16 lists the results in terms of heat loss coefficient F_2, based on degree-days.

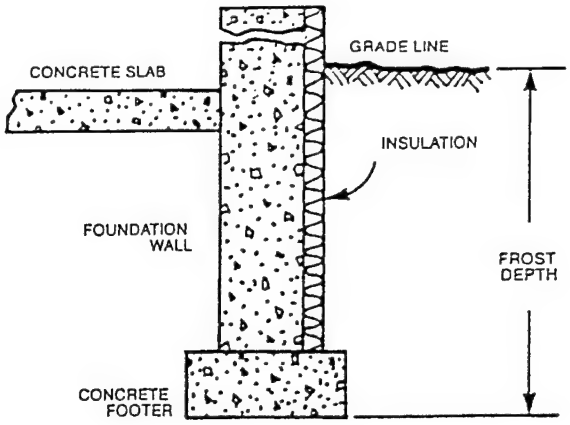

Fig. 7 "I"-Shaped or Vertical Insulation System

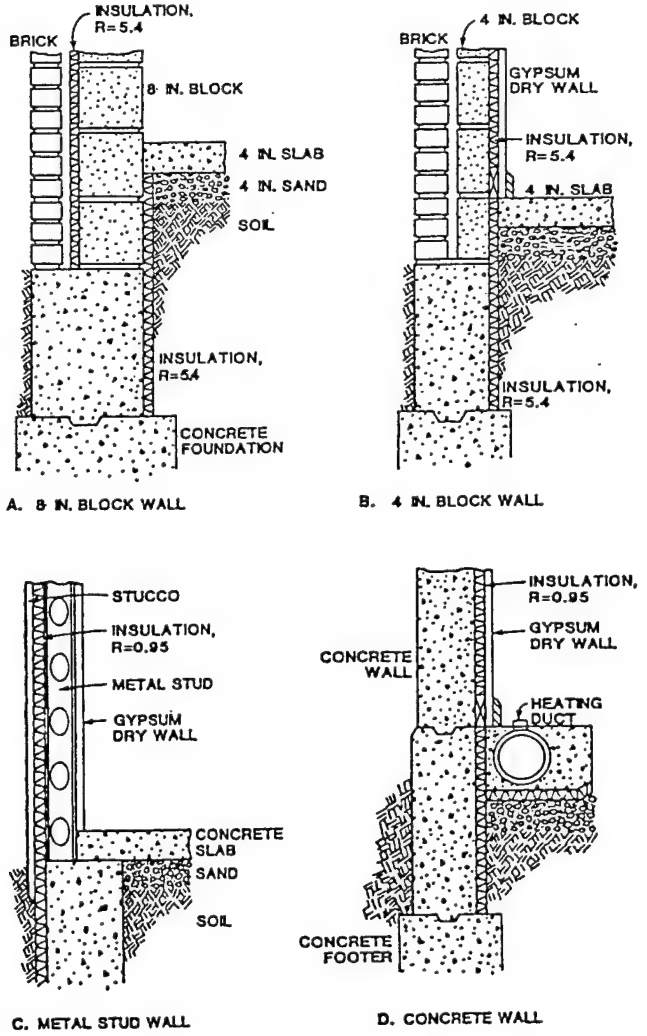

Fig. 8 Slab-on-Grade Foundation Insulation

Table 16 shows that the heat loss coefficient F_2 is sensitive to both construction and insulation. The reverse loss, or heat loss into the ground and outward through the edges of the slab and foundation wall, is significant when heating pipes, heating ducts, or baseboard heaters are placed near the slab perimeters. To prevent reverse loss, the designer may find it advantageous to use perimeter insulation even in warmer climates. For severe winter regions (above 6000 degree-days), the insulation value should be increased to $R > 10$ ft^2·°F·h/Btu.

Table 16 Heat Loss Coefficient F_2 of Slab Floor Construction, Btu/h·°F per ft of Perimeter

Construction	Insulation	Degree-Days (65°F Base) 7433	5350	2950
8 in. block wall, brick facing	Uninsulated	0.62	0.68	0.72
	R-5.4 from edge to footer	0.48	0.50	0.56
4 in. block wall, brick facing	Uninsulated	0.80	0.84	0.93
	R-5.4 from edge to footer	0.47	0.49	0.54
Metal stud wall, stucco	Uninsulated	1.15	1.20	1.34
	R-5.4 from edge to footer	0.51	0.53	0.58
Poured concrete wall with duct near perimeter[a]	Uninsulated	1.84	2.12	2.73
	R-5.4 from edge to footer, 3 ft under floor	0.64	0.72	0.90

[a]Weighted average temperature of the heating duct was assumed at 110°F during the heating season (outdoor air temperature less than 65°F).

Figure 8A shows that this construction benefits from the wall insulation between block and brick; the insulation is extended roughly 16 in. below the slab floor. Without this wall insulation, the heat loss coefficient F_2 would be close to that of the 4 in. block wall construction (Figure 8B). Table 16 can be used to estimate F_2 under different degree-days of heating season weather.

CALCULATING INFILTRATION HEAT LOSS

Infiltration of outside air causes both *sensible* and *latent* heat loss. The energy required to raise the temperature of outdoor infiltrating air to indoor air temperature is the sensible component. The energy associated with net loss of moisture from the space is the latent component. Infiltration is discussed in detail in Chapter 25.

Sensible Heat Loss

The energy required to warm outdoor air entering by infiltration to the temperature of the room is given by

$$q_s = c_p Q \rho (t_i - t_o) \tag{7}$$

where

q_s = heat flow required to raise temperature of air leaking into building from t_o to t_i, Btu/h
c_p = specific heat of air, Btu/lb·°F
Q = volumetric flow of outdoor air entering building, ft^3/h
ρ = density of air at temperature t_o, lb/ft^3

Using standard air (ρ = 0.075 lb/ft^3 and c_p = 0.24 Btu/lb·°F), Equation (7) reduces to

$$q_s = 0.018 Q (t_i - t_o) \tag{8}$$

The volumetric flow Q of outdoor air entering depends on wind speed and direction, width of cracks or size of openings, type of openings, and other factors explained in Chapter 25. Two methods used to obtain the quantity of infiltration air are the *crack length* and the *air change*. Louvers and doors and the direction they face, as well as any other factors affecting infiltration, may need to be considered.

Latent Heat Loss

When moisture must be added to the indoor air to maintain winter comfort conditions, the energy needed to evaporate an amount of water equivalent to what is lost by infiltration (latent component of infiltration heat loss) must be determined. This energy may be calculated by

$$q_l = Q \rho (W_i - W_o) h_{fg} \tag{9}$$

5/2

where

q_l = heat flow required to increase moisture content of air leakage into building from W_o to W_i, Btu/h
Q = volumetric flow of outdoor air entering building, ft^3/h
ρ = density of air at temperature t_i, lb/ft^3
W_i = humidity ratio of indoor air, $lb/lb_{dry\ air}$
W_o = humidity ratio of outdoor air, $lb/lb_{dry\ air}$
h_{fg} = latent heat of vapor at t_i, Btu/lb

If the latent heat of vapor h_{fg} is 1076 Btu/lb, and the air density is 0.075 lb/ft^3, Equation (7) reduces to

$$q_l = 80.7Q(W_i - W_o) \tag{10}$$

Crack Length Method

The basis of calculation for the crack method is that the amount of crack used for computing the infiltration heat loss should not be less than one-half the total length of crack in the outside walls of the room. In a building without partitions, air entering through cracks on the windward side must leave through cracks on the leeward side. Therefore, one-half the total crack for each side and end of the building is used for calculation. In a room with one exposed wall, all the crack is used. With two, three, or four exposed walls, either the wall with the crack that will result in the greatest air leakage or at least one-half the total crack is used, whichever is greater.

In residences, total infiltration loss of the house is generally considered equal to the sum of infiltration losses of the various rooms. But, at any given time, infiltration takes place only on the windward side or sides and not on the leeward. Therefore, for determining total heat requirements of larger buildings, it is more accurate to base total infiltration loss on the wall with the most total crack or on at least half the total crack in the building, whichever is greater. When the crack method rather than Equations (8) and (10) is used for estimating leakage, the heat loss in terms of the crack length may be expressed as

$$q_s = 0.018BL(t_i - t_o) \tag{11}$$

and

$$q_l = 80.7BL(W_i - W_o) \tag{12}$$

where

B = air leakage for wind velocity and type of window or door crack involved, ft^3/h per foot of crack
L = length of window or door crack to be considered, ft

Air Change Method

Some designers base infiltration on an estimated number of air changes rather than the length of window cracks. The number of air changes given in Chapter 25 should be considered only as a guide. When calculating infiltration losses by the air change method, Equations (8) and (10) can be used by substituting for Q the volume of the room multiplied by the number of air changes.

Exposure Factors

Some designers use empirical exposure factors to increase calculated heat loss of rooms or spaces on the side(s) of the building exposed to prevailing winds. However, exposure factors are not needed with the method of calculating heat loss described in this chapter. Instead, they may be (1) regarded as safety factors to allow for additional capacity for rooms or spaces exposed to prevailing winds or (2) used to account for the effects of radiation loss, particularly in the case of multistory buildings. Tall buildings may have severe infiltration heat losses induced by stack effect that require special analysis. Although a 15% exposure allowance is often assumed, the actual allowance, if any, is largely a matter of experience and judgment; no test data are available from which to develop rules for the many conditions encountered.

PICKUP LOAD

For intermittently heated buildings and night thermostat setback, additional heat is required to raise the temperature of air, building materials, and material contents of a building to the specified temperature. The pickup load, which is the rate at which this additional heat must be supplied, depends on the heat capacity of the structure, its material contents, and the time in which these are to be heated.

Relatively little information on pickup load exists; however, some early work by Smith (1941, 1942) addressed pickup loads for buildings heated only occasionally, such as auditoriums and churches. Nelson and MacArthur (1978) studied the relationship between thermostat setback, furnace capacity, and recovery time. Based on this limited information, the following design guidelines are offered.

Because design outdoor temperatures generally provide a substantial margin for outdoor temperatures typically experienced during operating hours, many engineers make no allowance for this additional heat in most buildings. However, if a minimum safety factor is to be used, the additional heat should be computed and allowed for, as conditions require. In the case of intermittently heated buildings, an additional 10% capacity should be provided.

In buildings with setback-type thermostats, the furnace must be oversized to allow for reestablishing the space temperature in an acceptable time. The amount of oversizing depends on many factors, such as the amount of setback, inside-to-outside temperature difference, building construction, and acceptable pickup time. Figure 9 indicates this relationship for a particular residence. As a general rule for residences, a 10°F night setback requires 40% oversizing for acceptable pickup time and minimum energy requirements (Nelson and MacArthur 1978). For smaller setback, the oversizing can be proportionally less. If daytime as well as night setback is practiced, oversizing of up to 60% is warranted.

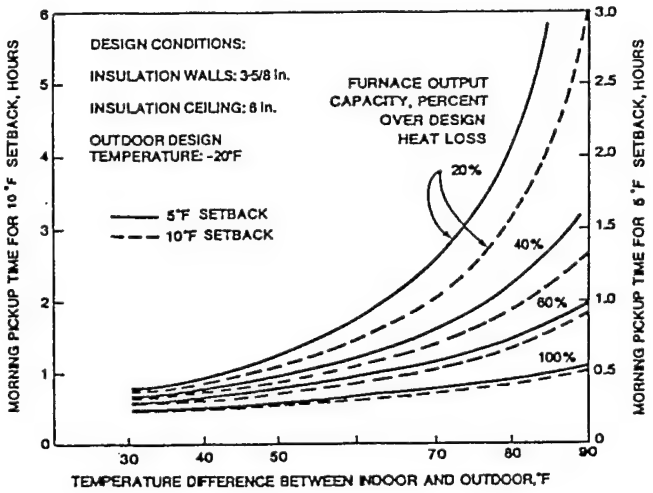

Fig. 9 Furnace Operating Times Required to Pick Up Space Temperature Following 5 and 10°F Night Setback

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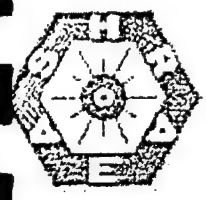

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CHAPTER 26

CLIMATIC DESIGN INFORMATION

The preparation of this chapter is assigned to TC 4.2, Weather Information.

THIS chapter provides tables of climatic conditions for 1459 locations in the United States, Canada, and around the world. These summaries include values of dry-bulb, wet-bulb, and dew-point temperature and wind speed with direction at various frequencies of occurrence. This information is commonly used for design, sizing, distribution, installation, and marketing of heating, ventilating, air-conditioning, and dehumidification equipment; as well as for other energy-related processes in residential, agricultural, commercial and industrial applications. Sources of other information such as degree days and typical weather years for energy calculations are also described.

UPDATED INFORMATION

A recent research project (ASHRAE 1997a) developed new design information for this chapter. Limited information on psychrometric conditions were provided in the 1993 *ASHRAE Handbook* through the design values of dry-bulb temperature with mean coincident wet-bulb temperature and the design wet-bulb temperature. Design values of wet-bulb and dew-point temperature with mean coincident dry-bulb temperature and humidity ratio are now included. These new data allow the designer to consider additional operational peak conditions. Motivated by a need for the design of smoke management systems, design values of wind speed have also been added (Lamming and Salmon 1994).

The design conditons in this chapter are provided for those locations for which long-term hourly observations were available (at least 12 years). Consequently, many United States locations listed in previous versions of this chapter are no longer listed because they lacked long-term data. The number of Canadian and international locations has increased significantly.

Design values of temperature and humidity have been updated from the 1993 *ASHRAE Handbook*. The temperature and humidity conditions previously provided for at the 1, 2.5, and 5 percentile frequency of occurrence during summer months have been replaced by conditions corresponding to annual percentile values of 0.4, 1 and 2. Winter month conditions for 99 and 97.5 percentiles have been replaced by conditions based on annual percentiles of 99.6 and 99. This change was made in order to provide design conditions representing the same probability of occurrence anywhere, regardless of the seasonal distribution of extreme temperature and humidity. Previously, the summer and winter months used for the calculation of design conditions varied depending on location. For instance, summer design conditions for the United States were calculated over the four month period from June through September, whereas Canadian summer design conditions were based on only the month of July. The following sections describe how the annual percentiles were chosen to yield design conditions that are similar to those previously calculated on a seasonal basis for most of the United States.

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily StdD DB Max.	Annual Extr. Daily StdD DB Min.
ALABAMA																							
Anniston	722287	33.58	85.85	610	14.374	8293	19	24	16	14	13	18	47	15	46	6	300	7	240	98	10	3.2	7.4
Birmingham	722280	33.57	86.75	630	14.364	6193	18	23	19	17	15	20	41	18	42	7	340	9	320	98	9	3.3	6.4
Bothan	722268	31.32	85.45	400	14.484	8293	28	32	18	17	15	19	45	17	47	9	320	8	320	99	16	1.6	7.2
Huntsville	723230	34.65	86.77	643	14.357	6193	15	20	23	20	18	23	40	21	40	10	340	10	270	97	7	3.0	7.5
Mobile	722230	30.68	88.25	220	14.579	6193	26	30	22	19	17	23	48	21	48	10	360	9	320	97	18	1.9	6.3
Montgomery	722260	32.30	86.40	203	14.588	6193	24	27	20	17	15	20	45	18	45	7	360	8	270	98	15	2.9	6.3
Muscle Shoals/Florence	723235	34.75	87.62	551	14.405	8293	16	21	18	16	14	19	42	17	42	9	360	7	290	98	7	3.1	9.2
Ozark, Fort Rucker	722269	31.28	85.72	299	14.538	8293	28	31	16	13	12	17	49	15	47	5	340	5	300	99	18	2.3	5.9
Tuscaloosa	722286	33.22	87.62	171	14.605	8293	20	24	17	14	13	18	47	16	51	5	360	7	240	99	11	1.8	6.8
ALASKA																							
Adak, NAS	704540	51.88	176.65	13	14.688	8293	19	23	34	30	27	40	34	34	35	4	210	10	170	67	11	3.4	2.9
Anchorage, Elemendorf	702720	61.25	149.80	213	14.583	8293	-13	-8	17	14	12	18	26	15	26	3	50	7	260	77	-18	3.2	6.5
Anchorage, Ft Richardson	702700	61.27	149.65	377	14.496	8293	-19	-13	19	14	11	20	35	15	36	3	50	5	270	80	-23	2.2	6.3
Anchorage, Int'l Airport	702730	61.17	150.02	131	14.626	6193	-14	-9	22	19	17	23	18	19	18	4	10	8	290	77	-18	2.9	7.2
Annette	703980	55.03	131.57	112	14.636	6193	13	17	31	27	23	31	41	28	40	10	40	8	320	81	10	3.8	5.4
Barrow	700260	71.30	156.78	13	14.688	6193	-41	-36	28	25	22	30	3	26	-1	7	140	12	90	65	-45	4.7	4.4
Bethel	702190	60.78	161.80	151	14.615	6193	-28	-24	31	27	24	34	8	30	5	13	20	12	360	78	-32	3.3	6.6
Bettles	701740	66.92	151.52	643	14.357	6193	-49	-44	18	16	14	19	11	16	7	2	340	8	190	85	-55	4.0	5.8
Big Delta, Ft. Greely	702670	64.00	145.73	1283	14.027	6193	-45	-39	34	29	25	38	0	33	3	3	180	9	180	84	-48	3.3	7.5
Cold Bay	703160	55.20	162.73	102	14.642	6193	6	10	38	34	30	46	34	40	34	15	340	16	140	67	2	4.0	5.3
Cordova	702960	60.50	145.50	43	14.673	8293	-4	1	22	19	16	24	40	22	38	1	340	8	240	79	-9	5.0	5.4
Deadhorse	700637	70.20	148.47	56	14.666	8293	-36	-34	32	28	25	34	-1	30	-7	12	240	12	60	78	-51	14.2	5.2
Dillingham	703210	59.05	158.52	95	14.645	8293	-20	-13	25	22	20	28	20	24	21	5	40	10	180	74	-27	3.1	9.4
Fairbanks, Eielson AFB	702650	64.67	147.10	548	14.407	8293	-33	-31	14	12	10	14	21	11	16	0	150	5	290	87	-46	3.8	7.7
Fairbanks, Int'l Airport	702610	64.82	147.87	453	14.457	6193	-47	-41	18	15	13	16	11	12	11	2	10	8	220	87	-48	3.8	7.8
Galena	702220	64.73	156.93	151	14.615	8293	-33	-31	18	15	13	19	14	16	15	0	270	5	320	84	-50	2.5	10.4
Gulkana	702710	62.15	145.45	1578	13.877	6193	-44	-39	26	24	21	22	17	19	18	3	360	7	180	82	-46	3.2	7.4
Homer	703410	59.63	151.50	72	14.657	8293	0	4	22	20	18	23	24	21	27	9	30	10	270	70	-5	4.0	6.8
Juneau	703810	58.37	134.58	23	14.683	8293	4	7	27	23	20	29	39	25	38	5	360	9	230	81	-1	2.5	4.9
Kenai	702590	60.57	151.25	95	14.645	8293	-22	-14	23	20	18	25	25	22	24	2	30	9	270	75	-27	3.4	7.4
Ketchikan	703950	55.35	131.70	95	14.645	8293	13	20	25	22	19	29	42	24	42	5	280	11	320	78	7	1.8	5.2
King Salmon	703260	58.68	156.65	49	14.669	6193	-24	-19	32	28	24	33	36	28	36	7	360	12	270	78	-31	3.5	7.2
Kodiak, State USCG	703500	57.75	152.50	112	14.636	6193	7	12	34	30	26	34	28	30	30	18	300	11	320	76	1	3.6	6.1
Kotzebue	701330	66.87	162.63	16	14.687	6193	-36	-31	35	31	28	38	14	32	14	7	70	12	300	75	-39	4.8	6.5
McGrath	702310	62.97	155.62	338	14.517	6193	-47	-42	18	16	14	18	23	14	12	1	310	7	340	83	-52	3.3	7.0
Middleton Island	703430	59.43	146.33	46	14.671	8293	18	21	40	34	30	42	35	37	36	18	330	8	260	66	15	4.9	6.8
Nenana	702600	64.55	149.08	361	14.505	8293	-51	-44	16	14	12	18	10	15	8	2	250	7	60	87	-52	4.1	7.2
Nome	702000	64.50	165.43	23	14.683	6193	-31	-26	30	26	23	31	17	28	18	4	20	12	260	76	-35	4.2	6.3
Northway	702910	62.97	141.93	1722	13.803	8293	-34	-32	15	13	12	14	-13	12	-6	0	300	7	290	83	-54	2.7	5.9
Port Heiden	703330	56.95	158.62	95	14.645	8293	-6	-2	38	32	28	38	36	32	35	17	60	15	160	74	-11	4.3	7.4
Saint Paul Island	703080	57.15	170.22	30	14.680	6193	-2	3	41	37	33	47	24	41	21	19	350	14	240	58	-3	5.2	6.9
Sitka	703710	57.07	135.35	66	14.661	8293	16	21	23	21	19	24	40	22	41	8	70	9	230	76	11	6.1	5.0
Talkeetna	702510	62.30	150.10	358	14.507	6193	-28	-21	17	16	14	19	13	17	15	4	50	8	200	82	-35	2.8	8.0
Valdez	702750	61.13	146.35	33	14.678	8293	4	7	24	19	16	28	13	22	15	15	70	10	240	76	1	3.6	6.1
Yakutat	703610	59.52	139.67	30	14.680	6193	-3	2	24	19	16	25	36	21	33	2	100	9	320	75	-8	4.0	7.0
ARIZONA																							
Flagstaff	723755	35.13	111.67	7011	11.335	6193	1	8	21	18	17	21	29	18	30	3	20	9	220	89	-10	2.5	7.3
Kingman	723700	35.27	113.95	3389	12.983	8293	22	27	26	23	20	24	46	21	43	5	90	13	240	103	15	1.8	6.8
Page	723710	36.93	111.45	4278	12.561	8293	20	24	19	16	13	16	42	12	40	4	300	7	360	104	8	3.6	12.2
Phoenix, Int'l Airport	722780	33.43	112.02	1106	14.118	6193	34	37	19	16	14	17	59	14	58	5	90	9	270	114	30	2.2	4.6
Phoenix, Luke AFB	722785	33.53	112.38	1089	14.126	8293	35	38	19	15	13	16	58	13	55	4	340	9	210	115	30	2.2	3.8
Prescott	723723	34.65	112.42	5043	12.208	6193	15	20	22	19	17	21	42	18	42	6	190	11	230	98	7	2.2	6.2
Safford, Agri Center	722747	32.82	109.68	3117	13.114	8293	21	26	17	14	12	15	50	13	48	4	110	7	310	106	11	3.8	11.5
Tucson	722740	32.12	110.93	2556	13.388	6193	31	34	24	21	18	24	56	21	56	7	140	12	300	108	25	2.8	4.0
Winslow	723740	35.02	110.73	4882	12.281	8293	10	14	26	22	19	24	46	19	45	5	140	9	250	100	3	4.9	6.3
Yuma	722800	32.65	114.60	207	14.586	8293	40	44	19	17	15	20	59	17	58	4	30	7	280	116	29	1.8	11.9
ARKANSAS																							
Blytheville, Eaker AFB	723408	35.97	89.95	256	14.560	8293	12	18	22	19	17	23	36	21	38	10	10	6	240	99	6	5.0	9.0
Fayetteville	723445	36.00	94.17	1250	14.044	8293	6	13	21	19	18	21	44	19	44	9	350	10	190	100	-1	3.2	9.2
Fort Smith	723440	35.33	94.37	463	14.451	6193	13	19	20	18	16	21	46	18	41	9	320	9	270	102	6	3.9	6.6
Little Rock, AFB	723405	34.92	92.15	312	14.531	6193	16	21	20	18	16	20	42	18	42	9	360	9	200	101	10	3.8	6.2
Texarkana	723418	33.45	93.98	390	14.489	8293	20	25	19	17	15	20	47	18	48	9	50	9	190	101	13	3.1	7.6
CALIFORNIA																							
Alameda, NAS	745060	37.78	122.32	13	14.688	8293	40	42	21	18	16	20	51	17	52	6	120	8	300	93	25	4.9	14.2
Arcata/Eureka	725945	40.98	124.10	217	14.581	6193	30	32	21	19	17	21	53	18	51	5	90	10	320	82	26	4.5	3.2
Bakersfield	723840	35.43	119.05	492	14.436	6193	32	35	19	16	14	19	56	14	54	5	90	12	310	108	28	2.3	3.4
Barstow/Daggett	723815	34.85	116.78	1926	13.701	6193	28	32	30	27	23	30	58	25	54	6	270	12	290	111	22	2.5	4.8
Blue Canyon	725845	39.28	120.72	5285	12.097	8293	21	24	15	12	11	16	35	14	35	5	70	6	290	89	11	3.8	18.4
Burbank/Glendale	722880	34.20	118.35	774	14.289	8293	39	41	18	14	12	20	56	17	57	2	330	8	180	106	33	3.1	4.5
Fairfield, Travis AFB	745160	38.27	121.93	62	14.662	8293	31	34	28	24	22	26	53	22	52	4	20	9	240	105	26	3.4	4.0
Fresno	723890	36.77	119.72	328	14.522	6193	30	32	17	15	13	17	53	14	52	4	90	9	290	107	26	2.2	3.8
Lancaster/Palmdale	723816	34.73	118.22	2346	13.492	8293	22	24	30	28	25	29	48	26	49	2	260	14	240	107	15	2.0	5.9
Lemoore, Reeves NAS	747020	36.33	119.95	236	14.570	8293	30	32	19	16	14	20	49	16	51	4	150	7	360	110	17	4.1	10.4
Long Beach	722970	33.82	118.15	39	14.675	6193	40	43	19	16	14	19	58	16	58	4	300	10	270	102	35	4.5	2.8

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily Std'D DB Max.	Annual Extr. Daily Std'D DB Min.
Los Angeles	722950	33.93	118.40	105	14.640	6193	43	45	21	18	16	20	56	17	56	6	70	10	250	97	38	5.1	3.0
Marysville, Beale AFB	724837	39.13	121.43	112	14.636	8293	31	34	20	17	14	23	53	19	53	3	20	5	200	106	26	3.2	4.1
Merced, Castle AFB	724810	37.38	120.57	187	14.596	8293	30	32	18	15	12	21	51	17	49	2	110	9	320	104	26	2.7	3.6
Mount Shasta	725957	41.32	122.32	3543	12.909	8293	16	21	14	12	10	14	36	12	37	4	60	4	180	95	10	2.7	6.7
Mountain View, Moffet	745090	37.42	122.05	39	14.675	8293	36	39	19	17	15	19	54	16	52	1	140	9	330	98	23	2.5	12.2
Ontario	722865	34.05	117.60	942	14.202	8293	35	38	22	19	17	28	62	21	57	4	10	13	240	108	29	3.4	2.5
Oxnard, PL Mugu NAWS	723910	34.12	119.12	7	14.692	8293	39	41	22	19	16	25	57	21	58	5	20	12	50	93	24	5.0	10.6
Paso Robles	723965	35.67	120.63	837	14.257	8293	26	29	22	20	18	21	52	18	51	3	110	11	300	108	21	2.2	4.9
Red Bluff	725910	40.15	122.25	354	14.508	8293	29	32	23	21	19	26	53	23	50	6	340	9	160	111	25	3.2	3.8
Riverside, March AFB	722860	33.88	117.27	1539	13.896	8293	34	36	18	15	13	22	51	18	55	1	210	9	300	107	29	2.3	3.2
Sacramento, Mather Fld	724835	38.55	121.30	95	14.645	8293	30	32	20	17	14	24	53	20	51	2	120	6	310	105	26	5.0	4.3
Sacramento, McClel AFB	724836	38.67	121.40	75	14.655	8293	31	34	20	16	14	23	53	19	52	2	340	5	220	107	27	2.5	4.9
Sacramento, Metro	724839	38.70	121.58	23	14.683	6193	31	33	22	19	17	23	51	20	50	3	340	8	220	107	27	6.6	3.0
Salinas	724917	36.67	121.60	85	14.650	8293	33	35	21	19	18	23	51	21	51	6	130	11	310	95	29	4.7	2.2
San Bernardino, Norton	722866	34.10	117.23	1158	14.091	8293	34	36	17	13	11	21	56	16	55	2	50	8	250	109	29	2.5	2.7
San Diego, Int'l Airport	722900	32.73	117.17	30	14.680	6193	44	46	18	16	15	20	59	16	60	3	70	10	310	95	39	6.4	4.4
San Diego, Miramar NAS	722930	32.85	117.12	420	14.474	8293	39	42	13	11	9	15	59	12	59	3	90	6	310	102	27	4.0	13.7
San Francisco	724940	37.62	122.38	16	14.687	6193	37	39	29	26	23	27	53	22	52	5	160	13	300	94	33	4.3	3.0
San Jose Int'l Airport	724945	37.37	121.93	56	14.666	8293	35	38	20	18	17	20	56	17	56	1	160	10	320	101	27	3.1	9.0
Santa Barbara	723925	34.43	119.83	10	14.690	8293	34	37	20	17	14	19	58	16	58	1	40	10	260	97	28	6.7	6.5
Santa Maria	723940	34.90	120.45	240	14.569	6193	32	35	23	21	19	21	59	18	59	4	110	11	300	95	27	5.0	2.8
Stockton	724920	37.90	121.25	26	14.681	8293	30	32	22	19	17	24	52	21	49	4	110	11	280	106	26	3.1	3.4
Victorville, George AFB	723825	34.58	117.38	2874	13.232	8293	27	30	22	19	16	22	49	18	47	3	160	9	180	106	21	3.1	5.6
COLORADO																							
Alamosa	724620	37.45	105.87	7543	11.108	6193	-17	-11	26	23	21	23	33	20	30	3	190	12	240	88	-27	2.0	7.9
Colorado Springs	724660	38.82	104.72	6171	11.701	6193	-2	4	29	25	21	28	35	23	33	7	20	12	160	95	-9	2.0	6.9
Craig	725700	40.50	107.53	6283	11.652	8293	-20	-12	26	20	17	22	33	17	27	2	270	9	250	93	-31	2.0	10.6
Denver	724699	39.75	104.87	5331	12.076	8293	-3	3	24	21	18	25	39	21	40	6	180	9	160	97	-11	2.3	7.0
Eagle	724675	39.65	106.92	6539	11.539	6193	-13	-7	22	19	17	20	33	18	32	3	90	11	230	93	-23	3.2	7.8
Grand Junction	724760	39.12	108.53	4839	12.301	6193	2	7	22	19	17	17	33	14	30	5	70	11	290	100	-3	2.0	8.5
Limon	724665	39.27	103.67	5364	12.062	8293	-6	1	27	23	21	27	29	22	25	9	160	12	200	96	-13	2.2	6.5
Pueblo	724640	38.28	104.52	4721	12.355	6193	-1	5	32	27	24	30	44	26	43	5	270	12	140	102	-12	1.9	7.7
Trinidad	724645	37.27	104.33	5761	11.883	8293	-2	6	25	22	19	24	41	21	42	5	290	10	210	98	-10	2.0	6.8
CONNECTICUT																							
Bridgeport	725040	41.17	73.13	16	14.687	6193	8	12	27	23	21	34	29	30	29	14	320	14	230	93	2	2.8	4.9
Hartford, Brainard Field	725087	41.73	72.65	20	14.685	6193	2	6	23	20	18	23	25	20	26	7	320	11	250	97	-6	2.4	5.7
Windsor Locks, Bradley	725080	41.93	72.68	180	14.600	8293	3	8	21	19	17	22	30	20	29	7	360	11	240	97	-5	2.0	5.8
DELAWARE																							
Dover, AFB	724088	39.13	75.47	30	14.680	8293	14	18	22	19	17	23	36	21	35	8	340	9	240	97	6	3.2	6.1
Wilmington	724089	39.68	75.60	79	14.654	6193	10	14	25	22	19	27	29	23	30	11	290	11	240	96	3	2.7	6.8
FLORIDA																							
Apalachicola	722200	29.73	85.03	20	14.685	8293	31	35	19	17	15	19	51	17	51	6	360	9	220	93	23	6.7	7.4
Cape Canaveral, NASA	747946	28.62	80.72	10	14.690	8293	38	42	19	17	15	21	60	19	60	8	320	8	220	96	29	1.4	6.1
Daytona Beach	722056	29.18	81.05	36	14.676	6193	34	37	21	19	17	22	61	19	61	7	310	11	240	96	27	1.9	4.4
Ft Lauderdale/Hollywood	722025	26.07	80.15	23	14.683	8293	46	50	22	20	18	22	69	20	71	9	330	11	120	97	39	1.1	6.1
Ft Myers	722106	26.58	81.87	16	14.687	8293	42	47	19	18	16	20	64	18	66	6	30	9	70	97	34	1.3	4.7
Gainesville	722146	29.68	82.27	151	14.615	8293	30	33	19	17	14	19	65	17	62	4	300	9	270	97	21	1.8	7.2
Homestead, AFB	722026	25.48	80.38	7	14.692	8293	48	52	17	15	13	17	70	15	70	6	360	7	120	95	41	2.2	5.6
Jacksonville, Cecil Field	722067	30.22	81.88	82	14.652	8293	31	34	18	16	14	19	62	17	62	3	290	7	270	100	20	2.0	8.8
Jacksonville, Int'l Airport	722060	30.50	81.70	30	14.680	6193	29	32	21	18	17	21	54	19	55	6	310	9	230	98	22	2.1	5.1
Jacksonville, Mayport	722066	30.40	81.42	16	14.687	8293	34	39	19	17	14	21	54	18	55	6	310	7	270	99	20	2.2	13.1
Key West	722010	24.55	81.75	20	14.685	6193	55	58	22	20	18	24	65	21	66	12	50	9	140	91	51	1.2	4.0
Melbourne	722040	28.10	80.65	36	14.676	8293	38	43	21	19	18	22	62	20	62	9	320	11	120	97	30	1.8	6.7
Miami, Int'l Airport	722020	25.82	80.28	13	14.688	6193	46	50	23	20	18	22	68	20	69	10	340	11	150	94	39	2.1	5.1
Miami, New Tamiami A	722029	25.65	80.43	10	14.690	8293	45	49	21	19	18	21	72	19	72	8	360	11	130	95	39	2.0	6.3
Milton, Whiting Field NAS	722226	30.72	87.02	200	14.589	8293	28	31	18	16	14	19	50	17	52	6	340	6	330	99	17	1.8	8.6
Orlando	722050	28.43	81.32	105	14.640	8293	37	42	20	18	16	21	66	19	65	8	330	9	290	96	29	1.6	6.5
Panama City, Tyndall AFB	747750	30.07	85.58	16	14.687	8293	33	37	18	16	14	19	52	17	52	9	360	7	240	94	24	2.3	6.3
Pensacola, Sherman AFB	722225	30.35	87.32	30	14.680	8293	28	32	23	20	18	25	43	22	48	9	360	10	200	100	15	6.3	7.6
Saint Petersburg	722116	27.92	82.68	10	14.690	8293	43	47	21	19	17	22	65	20	63	11	10	10	230	97	35	1.8	4.7
Sarasota/Bradenton	722115	27.40	82.55	30	14.680	8293	39	43	22	19	17	23	67	20	67	5	40	9	270	97	29	1.6	12.1
Tallahassee	722140	30.38	84.37	69	14.659	6193	25	28	18	16	14	19	52	17	54	3	350	8	360	98	17	2.0	4.6
Tampa, Int'l Airport	722110	27.97	82.53	10	14.690	6193	36	40	19	17	15	21	59	19	59	8	20	10	270	95	29	1.2	4.8
Valparaiso, Eglin AFB	722210	30.48	86.53	85	14.650	8293	30	33	19	16	14	18	49	16	51	6	360	7	210	97	19	2.0	6.1
Vero Beach	722045	27.65	80.42	26	14.681	8293	39	43	20	19	17	21	67	19	67	8	310	11	240	96	31	2.0	6.5
West Palm Beach	722030	26.68	80.12	20	14.685	6193	43	47	24	21	19	24	69	21	70	9	320	12	110	94	35	2.0	5.0
GEORGIA																							
Albany	722160	31.53	84.18	194	14.593	8293	27	30	19	17	15	19	50	18	50	4	360	9	250	100	17	2.2	7.2
Athens	723110	33.95	83.32	810	14.270	6193	20	25	19	17	15	20	40	18	40	10	290	9	270	98	11	3.5	6.6
Atlanta	722190	33.65	84.42	1033	14.155	6193	18	23	22	19	17	23	37	21	36	12	320	9	300	96	9	3.5	7.3
Augusta	722180	33.37	81.97	148	14.617	6193	21	25	20	18	15	21	45	19	46	5	290	9	250	100	13	3.7	5.6
Brunswick	722137	31.15	81.38	20	14.685	8293	30	34	18	17	16	19	49	18	49	8	350	10	250	98	22	2.5	7.7
Columbus, Fort Benning	722250	32.33	85.00	233	14.572	8293	23	27	16	13	11	17	46	15	46	3	320	5	240	100	14	2.9	6.7
Columbus, Metro Airport	722255	32.52	84.93	397	14.486	6193	23	27	17	15	14	18	44	16	46	7	310	9	310	99	14	2.3	6.1
Macon	722170	32.70	83.65	361	14.505	6193	23	27	19	17	15	20	46	18	45	7	320	9	270	100	14	2.7	6.4

Table 1A Heating and Wind Design Conditions—United States

Station	WMO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily StdD DB Max.	Annual Extr. Daily StdD DB Min.
Marietta, Dobbins AFB	722270	33.92	84.52	1070	14.136	8293	21	26	18	16	13	20	35	18	38	9	340	6	300	97	12	3.6	6.7
Rome	723200	34.35	85.17	643	14.357	8293	15	21	14	12	10	14	42	13	42	5	340	6	270	98	4	3.8	7.0
Savannah	722070	32.13	81.20	49	14.669	6193	26	29	20	17	15	21	49	19	49	7	270	9	270	98	18	3.0	5.4
Valdosta, Moody AFB	747810	30.97	83.20	233	14.572	8293	30	34	15	13	12	16	53	14	52	4	360	5	300	99	21	2.5	7.6
Valdosta, Regional A	722166	30.78	83.28	203	14.588	8293	28	31	17	15	14	18	55	16	56	4	340	8	300	99	17	3.2	7.7
Waycross	722130	31.25	82.40	151	14.615	8293	29	32	16	14	12	16	52	14	52	4	250	7	240	98	21	7.0	7.6
HAWAII																							
Ewa, Barbers Point NAS	911780	21.32	158.07	49	14.669	8293	59	61	20	18	16	22	73	19	75	5	40	11	60	93	35	1.6	21.4
Hilo	912850	19.72	155.07	36	14.676	6193	61	63	19	16	14	21	76	18	76	7	230	12	110	88	58	1.6	1.8
Honolulu	911820	21.35	157.93	16	14.687	6193	61	63	23	21	20	23	74	21	75	5	320	15	60	91	58	1.9	2.2
Kahului	911900	20.90	156.43	66	14.661	6193	59	61	27	25	24	32	76	28	76	6	160	19	50	92	54	1.5	4.4
Kaneohe, MCAS	911760	21.45	157.77	10	14.690	8293	67	68	20	18	17	21	74	19	74	7	190	10	70	88	40	1.4	29.0
Lihue	911650	21.98	159.35	148	14.617	6193	60	62	26	24	21	25	73	23	73	8	270	14	60	87	57	1.4	3.0
Molokai	911860	21.15	157.10	449	14.458	8293	60	61	24	22	21	22	74	21	74	4	70	13	60	92	43	4.0	22.0
IDAHO																							
Boise	726810	43.57	116.22	2867	13.235	6193	2	9	24	21	18	22	37	19	37	6	130	11	320	103	-4	2.7	9.1
Burley	725867	42.55	113.77	4150	12.621	8293	-5	2	23	21	19	23	30	22	28	7	60	8	280	98	-11	4.0	8.5
Idaho Falls	725785	43.52	112.07	4741	12.346	8293	-12	-6	27	23	21	28	32	23	29	7	360	12	180	96	-20	3.6	9.0
Lewiston	727830	46.38	117.02	1437	13.948	8293	6	15	20	17	14	24	38	20	40	5	280	7	310	103	3	2.7	9.9
Mountain Home, AFB	726815	43.05	115.87	2995	13.173	8293	0	5	23	21	18	23	33	21	31	2	90	8	350	105	-6	3.2	8.5
Mullan	727836	47.47	115.80	3317	13.017	8293	-1	7	10	10	9	11	18	9	21	2	10	4	10	92	-7	2.0	7.9
Pocatello	725780	42.92	112.60	4478	12.468	6193	-7	0	29	25	23	30	36	27	36	6	50	11	250	98	-15	2.3	9.1
ILLINOIS																							
Belleville, Scott AFB	724338	38.55	89.85	453	14.457	8293	3	10	21	18	15	23	32	20	31	7	360	7	190	100	-3	3.1	7.2
Chicago, Meigs Field	725340	41.78	87.75	623	14.367	8293	-4	3	23	22	19	26	17	23	30	12	240	13	220	97	-10	3.2	8.1
Chicago, O'Hare Int'l A	725300	41.98	87.90	673	14.342	6193	-6	-1	26	23	21	27	24	23	23	10	270	12	230	96	-12	2.8	6.5
Decatur	725316	39.83	88.87	682	14.337	8293	-2	3	24	22	20	27	24	24	27	13	310	12	210	99	-10	5.8	7.2
Glenview, NAS	725306	42.08	87.82	653	14.352	8293	-3	4	22	19	17	23	17	20	25	11	250	10	240	98	-10	3.1	7.7
Marseilles	744600	41.37	88.68	738	14.308	8293	-5	1	26	22	20	28	18	25	21	12	290	10	250	96	-11	4.0	5.9
Moline/Davenport IA	725440	41.45	90.52	594	14.383	6193	-8	-3	26	23	20	28	16	24	18	9	290	12	200	97	-14	2.7	6.0
Peoria	725320	40.67	89.68	663	14.347	6193	-6	-1	25	22	20	26	16	23	19	9	290	11	180	96	-12	3.3	6.1
Quincy	724396	39.95	91.20	768	14.292	8293	-4	2	26	23	20	28	23	24	22	12	330	12	210	97	-10	3.6	8.1
Rockford	725430	42.20	89.10	741	14.306	6193	-10	-4	26	23	21	26	18	23	20	9	290	13	200	95	-16	3.1	5.5
Springfield	724390	39.85	89.67	614	14.373	6193	-4	2	25	23	21	27	25	24	27	10	270	12	230	97	-11	2.8	5.5
West Chicago	725305	41.92	88.25	758	14.297	8293	-7	0	23	21	19	25	13	23	20	11	290	11	240	96	-14	3.2	7.7
INDIANA																							
Evansville	724320	38.05	87.53	387	14.491	6193	3	9	22	19	17	22	33	20	34	7	320	9	240	97	-4	2.7	8.5
Fort Wayne	725330	41.00	85.20	827	14.262	6193	-4	2	25	23	20	27	19	24	22	10	250	12	230	95	-11	3.6	5.2
Indianapolis	724380	39.73	86.27	807	14.272	6193	-3	3	24	21	19	25	26	22	27	8	230	11	230	94	-10	2.8	6.8
Lafayette, Purdue Univ	724386	40.42	86.93	607	14.376	8293	-5	3	22	20	18	24	26	22	27	9	270	12	220	97	-11	3.8	7.7
Peru, Grissom AFB	725335	40.65	86.15	810	14.270	8293	-3	4	24	21	18	29	20	24	22	11	270	9	210	96	-8	3.8	7.4
South Bend	725350	41.70	86.32	774	14.289	6193	-2	3	25	23	20	26	22	23	23	13	230	12	230	95	-10	3.3	5.8
Terre Haute	724373	39.45	87.32	584	14.388	8293	-3	5	23	20	18	23	31	21	32	8	150	11	230	96	-10	3.2	7.9
IOWA																							
Burlington	725455	40.78	91.13	699	14.328	8293	-4	1	21	19	17	24	12	21	18	9	310	11	200	98	-10	4.0	6.8
Cedar Rapids	725450	41.88	91.70	869	14.240	8293	-11	-5	25	22	20	29	12	26	14	10	300	11	180	96	-15	3.6	5.4
Des Moines	725460	41.53	93.65	965	14.190	6193	-9	-4	27	24	21	28	14	24	19	11	320	12	180	98	-15	3.4	5.1
Fort Dodge	725490	42.55	94.18	1165	14.087	8293	-13	-7	27	23	21	29	10	26	10	11	340	11	190	96	-17	4.9	4.9
Lamoni	725466	40.62	93.95	1122	14.109	8293	-6	0	19	17	15	21	23	19	20	7	320	9	210	99	-12	4.3	6.8
Mason City	725485	43.15	93.33	1214	14.062	6193	-15	-10	27	23	22	30	9	27	12	12	300	14	200	97	-23	3.6	11.4
Ottumwa	725465	41.10	92.45	846	14.251	8293	-5	0	29	26	23	31	20	28	24	13	320	15	200	98	-12	4.0	6.8
Sioux City	725570	42.40	96.38	1102	14.119	6193	-11	-6	29	25	22	31	14	28	16	11	320	14	180	99	-18	3.6	4.7
Spencer	726500	43.17	95.15	1339	13.998	8293	-16	-11	24	22	20	25	13	23	13	10	300	12	180	99	-20	6.3	4.0
Waterloo	725480	42.55	92.40	879	14.234	6193	-14	-9	27	24	22	29	10	25	13	9	300	13	180	96	-20	3.5	5.9
KANSAS																							
Concordia	724580	39.55	97.65	1483	13.925	8293	-4	3	28	25	22	28	32	25	32	13	360	16	10	104	-8	4.0	9.4
Dodge City	724510	37.77	99.97	2592	13.370	6193	0	6	30	27	24	31	31	27	32	13	10	17	200	104	-6	2.8	5.6
Ft Riley, Marshall AAF	724550	39.05	96.77	1066	14.138	8293	-2	5	21	18	16	20	39	18	37	5	350	9	180	104	-5	3.1	9.0
Garden City	724515	37.93	100.72	2890	13.224	8293	-3	4	30	26	23	29	32	25	34	12	360	16	190	104	-9	2.7	6.5
Goodland	724650	39.37	101.70	3688	12.840	6193	-3	2	32	28	24	31	27	27	30	12	270	13	180	102	-11	2.9	6.6
Russell	724585	38.87	98.82	1864	13.732	8293	-4	3	29	26	23	29	33	25	35	11	10	16	190	105	-8	3.6	8.5
Salina	724586	38.80	97.65	1273	14.032	8293	-3	4	27	23	22	28	33	24	34	11	360	15	180	106	-7	2.3	9.9
Topeka	724560	39.07	95.62	886	14.231	6193	-2	4	25	22	20	25	28	22	29	9	320	12	180	100	-8	3.8	7.4
Wichita, Airport	724500	37.65	97.43	1339	13.998	6193	2	8	29	25	23	28	30	26	31	13	360	16	200	105	-4	2.9	6.3
Wichita, McConnell AFB	724505	37.62	97.27	1371	13.982	8293	2	10	25	23	20	25	38	23	36	11	360	12	190	105	-1	2.7	7.7
KENTUCKY																							
Bowling Green	746716	36.97	86.42	548	14.407	8293	7	14	20	19	17	21	40	19	40	6	220	9	230	97	-2	3.2	10.3
Covington/Cincinnati A	724210	39.05	84.67	876	14.236	6193	1	7	22	20	18	25	30	22	33	9	250	10	230	95	-7	3.1	8.5
Fort Campbell, AAF	746710	36.67	87.50	571	14.395	8293	9	15	19	16	14	20	40	17	43	4	330	6	240	98	0	3.1	9.5
Fort Knox, Godman AAF	724240	37.90	85.97	755	14.299	8293	9	15	17	15	13	18	42	16	39	4	290	6	270	97	0	4.1	7.9
Jackson	724236	37.60	83.32	1381	13.977	8293	7	14	17	14	13	18	44	16	40	7	230	6	230	94	-3	2.7	9.4
Lexington	724220	38.03	84.60	988	14.179	6193	4	10	21	19	17	23	38	20	38	8	270	9	240	94	-4	3.5	8.3
Louisville	724230	38.18	85.73	489	14.438	6193	6	12	22	19	17	22	40	20	34	10	290	10	250	96	-1	3.1	7.9
Paducah	724350	37.07	88.77	413	14.477	8293	7	13	22	19	17	22	45	19	42	8	40	9	180	98	-1	2.9	9.4

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily StdD DB Max.	Annual Extr. Daily StdD DB Min.
LOUISIANA																							
Alexandria, England AFB	747540	31.33	92.55	89	14.648	8293	27	30	16	13	12	17	53	15	49	7	360	3	180	98	20	2.2	6.3
Baton Rouge	722317	30.53	91.15	69	14.659	6193	27	30	20	18	16	21	48	19	49	8	360	8	270	97	20	2.2	5.4
Bossier City, Barksdale	722485	32.50	93.67	167	14.607	8293	22	27	18	16	14	19	49	16	51	7	360	5	180	99	15	2.3	6.7
Lafayette	722405	30.20	91.98	43	14.673	8293	28	32	21	18	16	21	54	19	53	9	10	8	200	97	19	1.6	8.1
Lake Charles	722400	30.12	93.22	33	14.678	6193	29	32	22	19	17	24	50	21	49	10	20	8	230	96	23	2.3	4.7
Leesville, Fort Polk	722390	31.05	93.20	328	14.522	8293	27	30	16	13	12	16	51	14	52	4	20	4	180	98	20	2.0	5.9
Monroe	722486	32.52	92.03	79	14.654	8293	22	27	19	17	15	20	50	18	47	9	10	7	230	99	17	1.8	8.5
New Orleans, Int'l Airport	722310	29.98	90.25	30	14.680	6193	30	34	21	19	17	21	48	19	49	7	340	8	360	96	23	2.0	5.3
New Orleans, Lakefront A	722315	30.05	90.03	10	14.690	8293	35	39	22	19	18	21	49	20	50	14	360	9	300	94	21	8.1	12.4
Shreveport	722480	32.47	93.82	259	14.558	6193	22	26	20	18	16	22	46	19	48	9	360	8	180	99	16	3.1	5.6
MAINE																							
Augusta	726185	44.32	69.80	351	14.510	8293	-3	1	23	21	19	25	20	22	22	10	320	11	210	93	-10	3.1	3.4
Bangor	726088	44.80	68.83	194	14.593	8293	-7	-2	22	19	17	24	18	21	20	6	300	10	240	94	-16	2.9	5.9
Brunswick, NAS	743920	43.88	69.93	75	14.655	8293	-2	2	20	17	15	21	27	19	25	4	340	9	190	96	-12	7.9	6.1
Caribou	727120	46.87	68.02	623	14.367	6193	-14	-10	28	24	22	30	13	27	11	10	270	13	250	90	-23	2.8	4.5
Limestone, Loring AFB	727125	46.95	67.88	745	14.304	8293	-13	-9	23	20	18	25	12	22	11	7	300	9	260	91	-20	2.3	2.9
Portland	726060	43.65	70.32	62	14.662	6193	-3	2	24	21	18	24	26	21	25	7	320	12	270	93	-13	3.6	5.5
MARYLAND																							
Andrews AFB	745940	38.82	76.87	282	14.546	8293	13	18	21	18	16	23	30	21	32	7	350	9	230	98	4	2.9	6.7
Baltimore, BWI Airport	724060	39.18	76.67	154	14.614	6193	11	15	24	21	19	25	31	22	31	10	290	11	280	97	4	2.9	5.8
Fox Park, Patuxent River	724040	38.28	76.40	39	14.675	8293	16	21	20	17	15	22	30	19	35	9	340	9	270	98	8	2.3	6.1
Salisbury	724045	38.33	75.52	52	14.668	8293	13	18	20	18	16	20	35	19	37	6	10	9	240	97	4	2.7	5.8
MASSACHUSETTS																							
Boston	725090	42.37	71.03	30	14.680	6193	7	12	29	25	23	30	30	27	28	17	320	14	270	96	0	2.7	4.7
East Falmouth, Otis Angb	725060	41.65	70.52	131	14.626	8293	11	14	26	22	20	26	34	23	33	9	300	10	240	90	5	2.5	3.8
Weymouth, S Weymouth	725097	42.15	70.93	161	14.610	8293	6	11	19	16	14	18	29	16	29	7	320	9	260	97	-2	3.8	3.8
Worcester	725095	42.27	71.88	1010	14.167	6193	0	5	27	23	20	29	22	26	21	14	270	10	270	90	-6	1.9	4.1
MICHIGAN																							
Alpena	726390	45.07	83.57	692	14.332	6193	-7	-1	21	19	17	22	20	19	20	5	270	11	240	93	-17	3.4	5.9
Detroit, Metro	725370	42.23	83.33	663	14.347	6193	0	5	27	23	21	28	28	24	27	11	240	13	230	95	-7	3.0	5.4
Flint	726370	42.97	83.75	764	14.294	6193	-2	3	25	22	20	27	24	23	23	8	230	13	230	93	-10	3.1	5.0
Grand Rapids	726350	42.88	85.52	804	14.274	6193	0	5	25	22	20	26	25	23	24	8	180	13	240	93	-9	2.1	5.3
Hancock	727440	47.17	88.50	1079	14.131	6193	-9	-4	21	19	18	23	18	20	16	8	270	10	250	90	-16	2.9	5.6
Harbor Beach	725386	44.02	82.80	600	14.379	8293	9	12	26	22	19	26	27	23	27	10	220	9	230	94	2	2.9	4.1
Jackson	725395	42.27	84.47	1001	14.172	8293	-3	4	20	19	17	23	22	20	23	9	240	11	210	93	-11	2.5	5.6
Lansing	725390	42.77	84.60	873	14.238	6193	-3	2	26	23	20	28	23	25	24	8	290	13	250	94	-13	2.8	5.9
Marquette, Sawyer AFB	727435	46.35	87.40	1220	14.059	8293	-11	-6	24	21	18	26	18	23	17	6	280	10	210	91	-18	4.7	4.7
Marquette/Ishpeming, A	727430	46.53	87.55	1424	13.955	8293	-13	-8	22	19	18	22	20	20	16	8	270	11	230	90	-22	4.5	4.5
Mount Clemens, Angb	725377	42.62	82.83	581	14.390	8293	3	7	21	18	16	25	21	21	24	7	280	9	230	95	-3	4.0	2.7
Muskegon	726360	43.17	86.25	633	14.362	6193	3	7	27	24	22	28	25	25	26	10	290	12	200	90	-5	2.7	5.0
Oscoda, Wurtsmith AFB	726395	44.45	83.40	633	14.362	8293	0	3	21	19	17	23	26	21	24	6	220	11	200	95	-7	4.1	4.7
Pellston	727347	45.57	84.80	719	14.318	8293	-9	-3	26	23	20	28	22	24	22	4	300	14	250	92	-21	3.1	4.9
Saginaw	726379	43.53	84.08	669	14.343	8293	0	4	23	21	19	25	22	22	23	10	260	13	240	96	-6	5.8	4.5
Sault Ste. Marie	727340	46.47	84.37	725	14.314	6193	-12	-7	23	20	18	24	19	21	18	7	90	10	230	89	-22	3.5	5.4
Seul Choix Point	726399	45.92	85.92	591	14.385	8293	0	4	28	24	22	30	27	26	27	9	300	8	200	82	-5	2.3	6.3
Traverse City	726387	44.73	85.58	623	14.367	6193	-3	2	21	19	18	23	23	21	23	7	180	13	230	94	-13	2.8	7.3
MINNESOTA																							
Alexandria	726557	45.87	95.40	1424	13.955	8293	-20	-15	25	22	20	28	12	24	8	10	300	14	180	96	-26	3.6	4.5
Brainerd, Pequot Lakes	727500	46.60	94.32	1280	14.029	8293	-24	-17	11	10	9	11	8	10	11	3	320	5	190	95	-30	7.9	6.8
Duluth	727450	46.83	92.18	1417	13.958	6193	-21	-16	25	22	20	25	12	22	11	10	310	12	230	90	-28	2.8	4.7
Hibbing	727455	47.38	92.83	1352	13.992	8293	-25	-20	20	19	17	20	13	19	13	6	330	11	200	92	-34	2.5	4.7
International Falls	727470	48.57	93.38	1184	14.077	6193	-29	-23	22	20	18	22	10	20	8	6	270	11	180	92	-37	3.4	3.8
Minneapolis-St. Paul	726580	44.88	93.22	837	14.257	6193	-16	-11	25	22	20	25	12	22	14	9	300	14	180	97	-22	3.5	5.4
Redwood Falls	726556	44.55	95.08	1024	14.160	8293	-17	-12	26	22	20	28	14	24	15	11	280	14	180	99	-22	4.1	5.2
Rochester	726440	43.92	92.50	1319	14.008	6193	-17	-12	29	26	24	32	12	28	12	13	300	15	200	94	-23	3.7	5.2
Saint Cloud	726550	45.55	94.07	1024	14.160	6193	-20	-14	22	20	18	23	11	20	10	8	300	12	200	95	-27	3.0	5.6
Tofte	727554	47.58	90.83	791	14.280	8293	-10	-6	24	20	17	25	16	22	18	8	260	8	330	86	-19	4.5	4.9
MISSISSIPPI																							
Biloxi, Keesler AFB	747686	30.42	88.92	33	14.678	8293	31	35	17	14	13	18	49	16	50	8	360	7	210	97	23	2.0	7.4
Columbus, AFB	723306	33.65	88.45	220	14.579	8293	20	25	18	15	13	19	43	16	46	6	360	6	240	100	12	2.7	6.8
Greenwood	722359	33.50	90.08	154	14.614	8293	20	24	19	17	14	19	46	18	47	6	360	6	180	99	13	2.3	7.6
Jackson	722350	32.32	90.08	331	14.520	6193	21	25	20	18	16	21	45	19	46	7	340	8	270	98	14	2.7	5.8
McComb	722358	31.18	90.47	413	14.477	8293	23	28	17	14	13	17	49	15	49	6	350	7	230	98	15	2.0	7.2
Meridian	722340	32.33	88.75	308	14.532	6193	21	25	19	17	15	19	43	17	46	6	360	8	360	99	13	2.9	5.9
Tupelo	723320	34.27	88.77	361	14.505	8293	18	22	19	17	15	20	44	17	44	7	10	7	260	99	10	2.9	8.5
MISSOURI																							
Cape Girardeau	723489	37.23	89.57	341	14.515	8293	6	13	21	19	18	22	35	20	36	9	360	10	200	100	-1	2.9	9.2
Columbia	724450	38.82	92.22	899	14.224	6193	-1	5	25	22	20	25	27	22	28	11	310	11	200	99	-8	4.4	6.2
Joplin	723495	37.15	94.50	981	14.182	8293	3	11	23	21	19	24	50	21	47	10	10	11	220	100	-2	4.0	9.4
Kansas City	724460	39.32	94.72	1024	14.160	6193	-1	4	26	23	20	26	34	23	33	10	320	13	190	100	-7	4.1	6.5
Poplar Bluff	723300	36.77	90.47	479	14.443	8293	8	13	18	15	13	17	40	15	38	7	360	7	200	101	2	6.8	9.4
Spickard/Trenton	725400	40.25	93.72	886	14.231	8293	1	6	23	20	18	25	29	22	31	8	360	11	200	100	-5	5.2	7.4
Springfield	724400	37.23	93.38	1270	14.034	6193	3	9	24	21	19	23	35	21	35	10	340	10	230	98	-4	3.5	6.4

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily StdD DB Max.	Annual Extr. Daily StdD DB Min.
St. Louis, Int'l Airport	724340	38.75	90.37	564	14.398	6193	2	8	25	23	20	26	26	23	27	12	290	11	240	99	-5	3.5	6.2
Warrensburg, Whiteman	724467	38.73	93.55	869	14.240	8293	1	7	22	19	17	23	34	21	34	9	360	9	190	101	-5	4.0	7.7
MONTANA																							
Billings	726770	45.80	108.53	3570	12.896	6193	-13	-7	28	24	22	30	25	27	30	10	230	10	240	99	-19	2.8	6.2
Bozeman	726797	45.78	111.15	4475	12.469	8293	-20	-12	21	18	15	20	36	17	34	4	140	9	360	96	-29	2.9	7.7
Butte	726785	45.95	112.50	5545	11.980	8293	-22	-14	23	21	18	21	29	19	30	4	150	13	120	92	-34	2.5	7.9
Cut Bank	727796	48.60	112.37	3855	12.760	6193	-21	-16	34	30	27	40	36	34	36	7	320	13	270	93	-28	4.0	5.7
Glasgow	727680	48.22	106.62	2297	13.516	6193	-22	-17	29	26	23	28	18	25	15	8	330	13	160	99	-29	3.2	6.5
Great Falls, Int'l Airport	727750	47.48	111.37	3658	12.854	6193	-19	-13	33	29	26	34	38	31	38	7	240	12	230	98	-25	3.2	7.4
Great Falls, Malmstrom	727755	47.50	111.18	3527	12.917	8293	-17	-11	28	24	21	33	38	29	38	4	240	8	260	99	-22	3.2	7.9
Havre	727770	48.55	109.77	2598	13.367	8293	-25	-19	24	21	19	26	35	23	33	6	240	9	270	102	-33	5.0	8.1
Helena	727720	46.60	112.00	3898	12.740	6193	-18	-10	25	22	19	25	40	22	35	5	290	12	280	96	-24	3.3	7.2
Kalispell	727790	48.30	114.27	2972	13.184	6193	-12	-3	24	20	17	25	12	21	18	7	20	9	170	95	-19	2.9	8.6
Lewistown	726776	47.05	109.47	4167	12.613	6193	-18	-12	26	23	20	29	35	25	35	7	250	11	90	95	-25	3.5	7.3
Miles City	742300	46.43	105.87	2628	13.352	6193	-19	-13	27	23	20	28	25	23	27	8	290	11	140	102	-25	2.7	6.5
Missoula	727730	46.92	114.08	3189	13.079	6193	-9	-1	22	19	17	22	17	19	21	7	120	10	290	97	-15	2.9	8.2
NEBRASKA																							
Bellevue, Offutt AFB	725540	41.12	95.92	1047	14.148	8293	-5	1	22	19	17	26	23	22	23	8	330	10	190	100	-9	4.5	6.3
Grand Island	725520	40.97	98.32	1857	13.736	6193	-8	-2	30	26	23	29	21	26	19	11	270	15	180	102	-14	3.2	5.2
Lincoln	725510	40.85	96.75	1188	14.076	8293	-7	-2	27	23	21	28	25	24	27	9	350	15	180	103	-11	6.5	8.1
Norfolk	725560	41.98	97.43	1552	13.890	6193	-11	-5	29	25	22	33	20	28	21	11	340	15	190	101	-18	3.0	5.4
North Platte	725620	41.13	100.68	2785	13.275	6193	-10	-4	29	25	22	28	24	24	26	7	320	12	180	101	-16	2.9	6.6
Omaha, Eppley Airfield	725500	41.30	95.90	981	14.182	6193	-7	-2	26	23	20	27	21	23	17	10	340	12	180	100	-14	3.3	4.8
Omaha, Wso	725530	41.37	96.02	1332	14.002	8293	-8	-2	22	20	18	25	23	22	25	10	310	11	170	98	-14	4.0	6.5
Scottsbluff	725660	41.87	103.60	3957	12.712	6193	-11	-3	30	26	22	32	35	27	35	8	300	11	300	101	-19	2.9	8.0
Sidney	725610	41.10	102.98	4304	12.549	8293	-8	-1	29	24	22	31	32	26	35	9	290	12	160	101	-18	4.5	8.6
Valentine	725670	42.87	100.55	2598	13.367	8293	-16	-8	27	23	21	26	25	23	28	9	250	15	180	104	-22	4.3	8.5
NEVADA																							
Elko	725825	40.83	115.78	5135	12.166	6193	-5	1	21	18	16	20	36	16	37	4	70	10	230	98	-13	3.2	8.0
Ely	724860	39.28	114.85	6263	11.660	6193	-6	0	28	24	21	26	33	22	30	11	190	13	230	93	-15	2.3	7.3
Las Vegas, Int'l Airport	723860	36.08	115.17	2178	13.575	6193	27	30	30	26	23	25	48	22	49	7	250	12	230	111	21	2.2	4.7
Mercury	723870	36.62	116.02	3310	13.021	8293	24	28	25	22	19	25	44	21	42	8	50	12	230	102	19	17.6	6.3
North Las Vegas, Nellis	723865	36.23	115.03	1870	13.729	8293	28	31	24	21	18	23	52	19	49	2	20	9	210	112	21	2.0	4.5
Reno	724880	39.50	119.78	4400	12.505	6193	8	13	26	22	19	26	46	21	44	3	160	10	290	99	1	2.2	8.4
Tonopah	724855	38.05	117.08	5427	12.033	6193	7	13	25	22	20	24	37	22	36	9	340	12	180	98	1	2.0	6.5
Winnemucca	725830	40.90	117.80	4314	12.544	6193	1	7	23	19	17	21	39	18	38	5	160	11	250	101	-9	2.3	10.2
NEW HAMPSHIRE																							
Concord	726050	43.20	71.50	344	14.513	6193	-8	-2	23	20	17	23	20	20	21	4	320	10	230	95	-18	2.9	5.5
Lebanon	726116	43.63	72.30	597	14.381	8293	-7	-3	18	15	14	18	25	16	26	2	360	9	220	94	-17	2.0	5.2
Mount Washington	726130	44.27	71.30	6266	11.659	8293	-23	-19	88	81	73	99	-14	92	-15	73	280	21	270	65	-33	2.3	4.1
Portsmouth, Pease AFB	726055	43.08	70.82	102	14.642	8293	4	9	21	18	16	22	26	20	27	8	280	8	270	94	-2	2.2	3.2
NEW JERSEY																							
Atlantic City	724070	39.45	74.57	66	14.661	6193	8	13	27	23	20	29	36	25	34	9	310	11	250	96	0	2.9	5.7
Millville	724075	39.37	75.07	82	14.652	8293	10	15	19	18	17	20	35	19	35	7	300	11	240	96	0	2.3	7.4
Newark	725020	40.70	74.17	30	14.680	6193	10	14	26	23	20	27	28	23	29	13	260	13	230	98	4	2.6	4.8
Peterboro	725025	40.85	74.07	10	14.690	8293	10	14	21	19	17	21	29	19	30	11	280	12	240	97	2	2.5	5.6
Trenton, McGuire AFB	724096	40.02	74.60	135	14.624	8293	11	15	22	19	17	23	31	21	31	8	330	8	240	97	2	2.2	5.2
NEW MEXICO																							
Alamogordo, Holloman	747320	32.85	106.10	4094	12.647	8293	20	23	20	17	14	18	50	15	48	3	10	8	250	102	13	2.9	3.6
Albuquerque	723650	35.05	106.62	5315	12.084	6193	13	18	29	25	22	26	34	22	37	8	360	10	240	100	6	2.6	7.3
Carlsbad	722687	32.33	104.27	3294	13.028	8293	19	23	25	22	19	25	57	21	54	8	340	12	150	104	9	3.6	7.0
Clayton	723600	36.45	103.15	4970	12.241	8293	1	9	30	27	24	30	40	26	39	10	40	13	200	98	-5	2.5	7.4
Clovis, Cannon AFB	722686	34.38	103.32	4295	12.554	8293	10	15	26	23	20	26	40	23	39	8	50	11	220	101	5	2.3	4.0
Farmington	723658	36.75	108.23	5502	11.999	8293	8	13	23	21	18	22	35	19	34	6	60	10	240	99	-1	3.8	7.2
Gallup	723627	35.52	108.78	6470	11.570	8293	-1	5	23	20	18	19	39	18	37	1	140	11	270	94	-12	2.3	7.9
Roswell	722680	33.30	104.53	3668	12.849	8293	14	20	22	19	17	20	51	18	48	8	360	11	140	105	6	4.7	6.5
Truth Or Consequences	722710	33.23	107.27	4859	12.292	8293	22	26	25	21	18	24	43	21	41	8	350	10	170	102	6	2.9	23.8
Tucumcari	723676	35.18	103.60	4065	12.661	6193	9	15	25	22	20	28	50	23	45	8	50	12	230	102	1	3.1	7.2
NEW YORK																							
Albany	725180	42.75	73.80	292	14.541	6193	-7	-2	24	22	19	23	20	20	22	5	300	10	230	95	-18	3.0	6.3
Binghamton	725150	42.22	75.98	1631	13.850	6193	-2	2	24	21	19	24	20	22	19	13	270	11	220	89	-9	3.1	4.4
Buffalo	725280	42.93	78.73	705	14.325	6193	2	5	29	26	23	34	25	30	24	12	270	13	240	91	-6	2.3	5.3
Central Islip	725035	40.80	73.10	98	14.643	8293	11	15	22	20	18	23	32	21	31	10	340	11	210	94	2	3.2	5.4
Elmira/Corning	725156	42.17	76.90	955	14.195	8293	-2	3	21	19	17	23	20	20	27	5	240	11	210	95	-10	3.6	6.1
Glens Falls	725185	43.33	73.62	328	14.522	8293	-10	-4	18	16	14	19	22	17	22	2	350	10	190	93	-20	2.7	4.7
Massena	726223	44.93	74.85	213	14.583	6193	-15	-10	21	18	17	23	22	21	22	4	270	10	230	92	-27	3.0	6.0
New York, JFK Airport	744860	40.65	73.78	23	14.683	6193	11	15	27	24	21	30	29	27	28	17	320	13	230	96	6	2.6	4.6
New York, La Guardia A	725030	40.77	73.90	30	14.680	8293	13	17	28	25	22	30	29	27	28	18	310	12	280	97	6	2.2	4.3
Newburgh	725038	41.50	74.10	492	14.436	8293	6	10	23	20	18	26	17	23	26	8	260	10	230	92	-4	3.1	6.5
Niagara Falls	725287	43.10	78.95	591	14.385	8293	4	7	26	22	20	30	24	27	23	11	240	13	230	91	-4	3.2	6.1
Plattsburgh, AFB	726225	44.65	73.47	236	14.570	8293	-9	-4	21	18	16	22	27	19	24	2	350	8	260	93	-17	2.7	4.7
Poughkeepsie	725036	41.63	73.88	167	14.607	8293	2	6	18	16	14	19	25	17	25	3	250	9	250	96	-8	3.1	5.9
Rochester	725290	43.12	77.67	554	14.403	6193	1	5	27	23	21	29	22	26	21	10	230	12	250	93	-7	2.8	4.9
Rome, Griffiss AFB	725196	43.23	75.40	505	14.429	8293	-5	1	22	19	16	23	22	20	22	3	330	8	260	93	-15	2.5	3.8
Syracuse	725190	43.12	76.12	407	14.481	6193	-3	2	26	22	20	28	20	25	21	7	90	11	250	93	-13	3.0	6.0

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	2.5%	5%	Cldst Month WS/MDB 0.4% WS	0.4% MDB	1% WS	1% MDB	MWS/MWD to DB 99.6% MWS	99.6% MWD	0.4% MWS	0.4% MWD	Annual Extr. Daily Mean DB Max.	Mean DB Min.	StdD DB Max.	StdD DB Min.
Watertown	726227	44.00	76.02	325	14.524	8293	-12	-6	21	19	18	24	24	21	25	5	80	11	240	90	-25	2.9	7.0
White Plains	725037	41.07	73.70	440	14.463	8293	7	12	19	17	15	19	29	18	29	13	310	9	260	95	0	2.9	4.5
NORTH CAROLINA																							
Asheville	723150	35.43	82.55	2169	13.580	6193	11	16	25	22	19	26	26	23	28	11	340	9	340	91	3	2.6	6.8
Cape Hatteras	723040	35.27	75.55	10	14.690	6193	26	29	26	22	20	27	47	23	47	11	340	11	230	91	20	2.0	4.9
Charlotte	723140	35.22	80.93	768	14.292	6193	18	23	20	17	15	20	44	18	45	6	50	9	240	97	10	2.9	6.0
Cherry Point, Mcas	723090	34.90	76.88	30	14.680	8293	24	28	19	16	15	19	43	17	48	5	10	7	240	100	12	2.5	8.5
Fayetteville, Fort Bragg	746930	35.13	78.93	243	14.567	8293	22	27	17	14	12	19	42	16	44	4	10	6	240	100	15	3.8	6.8
Goldsboro, Johnson AFB	723066	35.33	77.97	108	14.638	8293	22	27	17	14	12	18	46	15	44	4	270	8	260	100	14	3.1	7.4
Greensboro	723170	36.08	79.95	886	14.231	6193	15	19	19	17	15	20	40	18	40	7	290	8	230	96	7	2.7	5.0
Hickory	723145	35.73	81.38	1188	14.076	8293	18	23	17	15	13	18	41	16	41	4	320	9	240	97	8	3.2	6.8
Jacksonville, New River	723096	34.72	77.45	26	14.681	8293	23	27	18	16	14	19	49	17	47	5	350	7	240	99	13	2.0	8.8
New Bern	723095	35.07	77.05	20	14.685	8293	22	27	18	16	14	19	49	17	47	6	10	8	240	99	13	1.4	8.3
Raleigh/Durham	723060	35.87	78.78	440	14.463	6193	16	20	21	18	16	21	42	19	43	8	360	9	240	96	9	2.9	5.3
Wilmington	723013	34.27	77.90	33	14.678	6193	23	27	21	19	17	22	51	20	48	7	320	10	220	97	17	2.2	5.7
Winston-Salem	723193	36.13	80.22	971	14.187	8293	18	23	19	17	15	21	38	19	38	7	290	8	240	96	8	2.7	5.8
NORTH DAKOTA																							
Bismarck	727640	46.77	100.75	1660	13.835	6193	-21	-16	29	25	22	29	13	25	16	7	290	13	180	100	-30	3.6	6.4
Devils Lake	727580	48.10	98.87	1453	13.940	8293	-23	-19	26	22	20	27	12	24	10	9	300	11	10	98	-27	7.0	5.0
Fargo	727530	46.90	96.80	899	14.224	6193	-22	-17	31	27	24	32	7	28	7	8	180	14	160	98	-27	3.4	4.4
Grand Forks, AFB	727575	47.97	97.40	912	14.217	8293	-20	-16	27	24	21	30	9	26	13	7	290	13	180	98	-25	4.7	4.9
Minot, AFB	727675	48.42	101.35	1667	13.832	8293	-21	-16	28	24	21	30	18	27	16	10	310	12	150	101	-25	3.8	7.4
Minot, Int'l Airport	727676	48.27	101.28	1716	13.807	6193	-20	-16	28	24	22	30	14	27	14	12	290	13	200	98	-25	3.0	4.8
Williston	727670	48.18	103.63	1906	13.711	8293	-24	-18	27	23	21	28	25	24	20	8	220	14	150	101	-30	4.5	8.3
OHIO																							
Akron/Canton	725210	40.92	81.43	1237	14.050	6193	0	5	24	21	19	25	26	22	26	11	270	10	230	92	-7	2.9	7.0
Cincinnati, Lunken Field	724297	39.10	84.42	482	14.441	8293	5	12	21	19	17	22	35	19	33	9	260	10	210	96	-3	3.2	9.4
Cleveland	725240	41.42	81.87	804	14.274	6193	1	6	26	23	20	27	28	24	28	12	230	12	230	93	-6	2.8	6.3
Columbus, Int'l Airport	724280	40.00	82.88	817	14.267	6193	1	6	23	20	18	24	30	21	25	9	270	11	270	94	-6	2.6	7.1
Columbus, Rickenbacker	724285	39.82	82.93	745	14.304	8293	3	10	21	18	16	23	26	20	27	7	210	8	270	96	-4	4.5	8.6
Dayton, Int'l Airport	724290	39.90	84.20	1004	14.170	6193	-1	5	24	21	19	25	26	22	28	11	270	11	240	95	-8	2.9	7.0
Dayton, Wright-Paterson	745700	39.83	84.05	823	14.263	8293	1	8	21	18	16	23	28	21	30	7	270	9	240	96	-7	3.2	7.7
Findlay	725366	41.02	83.67	810	14.270	8293	-2	4	23	20	19	25	34	22	29	11	250	12	210	94	-9	3.8	7.9
Mansfield	725246	40.82	82.52	1296	14.020	6193	-1	4	25	22	20	28	28	25	26	13	240	12	240	91	-8	2.8	6.0
Toledo	725360	41.60	83.80	692	14.332	6193	-2	3	23	20	18	25	25	22	21	10	250	11	230	95	-10	3.0	5.4
Youngstown	725250	41.27	80.67	1184	14.077	6193	-1	4	23	21	19	24	22	22	21	10	230	10	230	91	-8	2.5	5.8
Zanesville	724286	39.95	81.90	899	14.224	8293	2	9	19	18	16	21	32	19	31	7	240	9	220	94	-7	3.6	8.5
OKLAHOMA																							
Altus, AFB	723520	34.67	99.27	1378	13.978	8293	13	19	23	21	19	24	40	21	42	9	20	10	190	107	7	3.4	7.7
Enid, Vance AFB	723535	36.33	97.92	1306	14.015	8293	5	12	26	23	20	27	38	23	38	12	10	11	190	105	1	3.6	6.7
Lawton, Fort Sill/Post Fld	723550	34.65	98.40	1188	14.076	8293	12	19	24	21	19	26	35	22	36	11	10	11	170	103	8	2.5	7.4
McAlester	723566	34.88	95.78	771	14.291	8293	10	17	20	18	16	21	47	19	45	9	360	9	190	102	4	4.0	8.3
Oklahoma City, Tinker AFB	723540	35.42	97.38	1293	14.022	8293	10	17	24	22	19	25	42	22	42	10	10	11	190	103	6	3.2	6.1
Oklahoma City, Rogers A	723530	35.40	97.60	1302	14.017	6193	9	15	29	25	23	29	33	26	37	15	360	13	180	103	4	3.4	4.9
Tulsa	723560	36.20	95.90	676	14.340	6193	9	14	25	23	21	24	46	22	40	11	360	12	180	103	3	3.6	5.6
OREGON																							
Astoria	727910	46.15	123.88	23	14.683	6193	25	29	25	22	19	29	51	24	49	8	90	12	320	87	20	4.5	6.1
Eugene	726930	44.12	123.22	374	14.498	6193	21	26	20	18	16	22	46	19	45	8	360	12	360	99	16	3.7	7.9
Hillsboro	726986	45.53	122.95	203	14.588	8293	19	24	19	17	15	23	26	19	34	8	60	9	360	100	15	3.8	6.3
Klamath Falls	725895	42.15	121.73	4091	12.649	8293	4	10	25	22	19	28	39	23	33	6	320	9	320	97	-4	4.1	8.6
Meacham	726885	45.52	118.40	4055	12.666	8293	-9	0	12	10	9	13	33	11	33	1	130	5	360	93	-21	4.7	12.2
Medford	725970	42.37	122.87	1329	14.003	6193	21	24	19	16	13	20	51	15	50	3	130	9	290	104	15	3.4	6.4
North Bend	726917	43.42	124.25	13	14.688	6193	30	32	25	23	20	23	51	20	50	7	140	14	340	82	24	4.0	5.5
Pendleton	726880	45.68	118.85	1496	13.918	6193	3	11	28	24	20	27	44	23	42	6	140	9	310	102	-1	3.6	11.2
Portland	726980	45.60	122.60	39	14.675	6193	22	27	25	21	18	28	37	25	39	13	120	11	340	99	18	4.4	6.0
Redmond	726835	44.25	121.15	3077	13.133	6193	1	9	20	17	16	20	42	18	41	6	320	11	340	98	-7	3.2	10.2
Salem	726940	44.92	123.00	200	14.589	6193	20	25	23	19	17	25	46	22	46	6	350	10	360	100	14	3.3	6.6
Sexton Summit	725975	42.62	123.37	3842	12.767	8293	21	24	24	22	19	27	37	24	38	9	120	6	340	89	16	4.9	8.5
PENNSYLVANIA																							
Allentown	725170	40.65	75.43	384	14.493	6193	5	10	27	23	21	28	26	25	24	9	270	11	240	95	-2	2.8	5.2
Altoona	725126	40.30	78.32	1503	13.915	8293	5	10	20	18	17	23	20	20	22	9	270	8	250	92	-5	3.6	7.9
Bradford	725266	41.80	78.63	2142	13.593	6193	-6	-1	19	18	16	22	22	19	21	7	270	9	240	87	-15	2.8	5.0
Du Bois	725125	41.18	78.90	1818	13.756	8293	0	5	21	19	17	23	20	21	20	11	280	10	270	90	-9	3.1	7.0
Erie	725260	42.08	80.18	738	14.308	6193	2	7	27	24	22	29	28	26	28	14	200	12	250	90	-4	3.1	6.4
Harrisburg	725115	40.20	76.77	308	14.532	6193	9	13	22	20	18	24	29	22	29	8	270	10	250	97	2	3.3	5.7
Philadelphia, Int'l Airport	724080	39.88	75.25	30	14.680	6193	11	15	24	21	19	26	31	23	30	12	290	11	230	96	5	2.8	5.6
Philadelphia, Northeast A	724085	40.08	75.02	121	14.631	8293	11	15	21	19	17	22	30	19	29	10	300	10	260	97	3	2.5	6.1
Philadelphia, Willow Gr	724086	40.20	75.15	361	14.505	8293	10	14	18	15	13	19	30	16	30	5	300	6	250	99	2	5.4	5.8
Pittsburgh, Allegheny A	725205	40.35	79.93	1253	14.042	8293	4	11	21	19	17	23	24	21	24	11	250	11	240	94	-4	3.1	9.4
Pittsburgh, Int'l Airport	725200	40.50	80.22	1224	14.057	6193	2	7	25	21	19	26	24	23	25	10	260	11	230	93	-6	3.1	6.7
Wilkes-Barre/Scranton	725130	41.33	75.73	948	14.199	6193	2	7	20	18	16	21	26	19	25	8	230	11	220	92	-5	2.8	4.9
Williamsport	725140	41.25	76.92	525	14.419	6193	2	7	23	20	18	24	23	21	25	8	270	10	250	94	-6	3.1	5.9
RHODE ISLAND																							
Providence	725070	41.73	71.43	62	14.662	6193	5	10	27	23	21	27	31	23	32	12	340	13	230	95	-2	3.7	5.0

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	Extreme Wind Speed, mph 2.5%	Extreme Wind Speed, mph 5%	Cldst Month WS/MDB 0.4% WS	Cldst Month WS/MDB 0.4% MDB	Cldst Month WS/MDB 1% WS	Cldst Month WS/MDB 1% MDB	MWS/MWD to DB 99.6% MWS	MWS/MWD to DB 99.6% MWD	MWS/MWD to DB 0.4% MWS	MWS/MWD to DB 0.4% MWD	Annual Extr. Daily Mean DB Max.	Annual Extr. Daily Mean DB Min.	Annual Extr. Daily StdD DB Max.	Annual Extr. Daily StdD DB Min.
SOUTH CAROLINA																							
Beaufort, Mcas	722085	32.48	80.72	39	14.675	8293	28	31	18	15	13	19	46	17	45	4	300	7	270	101	13	2.9	8.3
Charleston	722080	32.90	80.03	49	14.669	6193	25	28	22	19	17	22	52	19	51	7	20	10	230	98	18	2.3	5.6
Columbia	723100	33.95	81.12	226	14.576	6193	21	24	20	17	15	20	48	18	49	5	220	9	240	100	13	3.1	5.6
Florence	723106	34.18	79.72	148	14.617	8293	23	27	19	17	15	20	51	18	50	7	360	10	240	100	14	2.7	7.6
Greer/Greenville	723120	34.90	82.22	971	14.187	6193	19	23	20	18	16	21	45	18	44	6	50	9	230	97	11	2.6	5.5
Myrtle Beach, AFB	747910	33.68	78.93	26	14.681	8293	25	29	18	15	13	18	49	15	47	4	360	7	290	98	17	2.9	7.4
Sumter, Shaw AFB	747900	33.97	80.47	243	14.567	8293	24	29	18	16	14	19	48	17	48	5	10	8	240	100	17	3.1	6.1
SOUTH DAKOTA																							
Chamberlain	726530	43.80	99.32	1739	13.795	8293	-13	-7	27	24	21	28	18	25	20	11	270	13	190	106	-12	8.1	18.4
Huron	726540	44.38	98.22	1289	14.024	6193	-17	-12	29	25	22	29	14	25	15	9	290	14	180	102	-25	4.6	5.9
Pierre	726686	44.38	100.28	1742	13.794	6193	-14	-9	29	25	22	32	15	27	20	11	320	14	180	106	-20	3.8	5.7
Rapid City	726620	44.05	103.07	3169	13.089	6193	-11	-5	36	31	27	37	26	32	26	9	350	13	160	102	-17	3.4	5.4
Sioux Falls	726510	43.58	96.73	1427	13.953	6193	-16	-11	28	25	22	30	15	26	17	8	310	15	180	100	-23	4.1	4.9
TENNESSEE																							
Bristol	723183	36.48	82.40	1519	13.906	6193	9	14	20	17	15	21	35	19	36	6	270	8	250	92	-1	3.0	7.5
Chattanooga	723240	35.03	85.20	689	14.333	6193	15	20	19	17	15	20	37	18	38	7	360	8	280	97	7	3.6	7.0
Crossville	723265	35.95	85.08	1880	13.724	8293	7	15	16	14	13	18	33	16	36	4	310	8	270	93	-3	4.0	8.6
Jackson	723346	35.60	88.92	433	14.467	8293	12	18	20	18	16	21	46	19	44	9	360	8	240	98	4	2.3	8.8
Knoxville	723260	35.82	83.98	981	14.182	6193	13	19	21	18	15	21	48	19	45	7	50	8	250	95	4	3.0	7.8
Memphis	723340	35.05	90.00	285	14.544	6193	16	21	22	19	17	22	42	20	42	10	20	9	240	99	9	2.8	7.2
Nashville	723270	36.13	86.68	591	14.385	6193	10	16	22	19	17	22	46	20	42	8	340	9	230	97	1	3.3	7.8
TEXAS																							
Abilene	722660	32.42	99.68	1791	13.769	6193	16	22	27	24	22	26	48	23	46	12	0	11	140	102	10	2.8	5.9
Amarillo	723630	35.23	101.70	3606	12.879	6193	6	12	30	27	24	30	40	27	38	14	20	15	200	100	-1	2.8	5.5
Austin	722540	30.30	97.70	620	14.369	6193	25	30	23	20	18	25	41	22	43	12	10	10	180	101	20	2.4	5.9
Beaumont/Port Arthur	722410	29.95	94.02	23	14.683	6193	29	32	22	20	18	23	51	21	51	10	340	9	200	97	22	2.5	4.5
Beeville, Chase Field	722556	28.37	97.67	190	14.595	8293	28	33	22	20	18	23	58	20	53	13	350	9	150	104	22	2.5	8.3
Brownsville	722500	25.90	97.43	20	14.685	6193	36	40	27	24	22	26	64	23	62	13	330	16	160	98	31	2.4	5.2
College Station/Bryan	722445	30.58	96.37	322	14.525	8293	22	29	21	19	17	21	47	19	49	12	350	9	170	101	17	2.3	8.3
Corpus Christi	722510	27.77	97.50	43	14.673	6193	32	36	28	25	23	27	59	24	58	13	360	15	140	98	25	1.9	5.2
Dallas/Fort Worth, Int'l A	722590	32.90	97.03	597	14.381	8293	17	24	26	23	21	26	46	24	47	13	350	10	170	103	14	3.1	8.3
Del Rio, Laughlin AFB	722615	29.37	100.78	1083	14.130	8293	28	32	22	19	17	22	47	19	50	7	10	9	140	105	22	3.1	5.8
El Paso	722700	31.80	106.40	3917	12.731	6193	21	25	25	21	18	24	51	21	49	5	20	8	180	104	14	3.3	6.1
Fort Worth, Carswell AFB	722595	32.77	97.45	650	14.354	8293	18	24	22	20	18	23	43	20	45	11	10	8	10	103	15	2.2	8.1
Fort Worth, Meacham Fld	722596	32.82	97.37	709	14.323	6193	19	24	27	24	21	27	40	24	44	13	350	10	180	103	14	3.0	5.8
Guadalupe Pass	722620	31.83	104.80	5453	12.022	8293	13	19	51	45	41	50	39	46	37	19	70	13	250	98	10	2.9	6.8
Houston, Hobby Airport	722435	29.65	95.28	46	14.671	8293	29	34	22	20	18	23	52	21	52	13	350	7	190	98	24	2.0	8.1
Houston, Inter Airport	722430	29.97	95.35	108	14.638	6193	27	31	20	18	16	22	47	20	52	8	340	10	180	98	22	3.1	5.4
Junction	747400	30.50	99.77	1713	13.808	8293	19	23	19	16	15	19	53	16	53	6	360	9	150	104	12	2.3	6.7
Killeen, Fort Hood	722576	31.07	97.83	1014	14.165	8293	20	27	22	19	17	22	48	19	53	11	360	9	160	102	15	2.0	8.6
Kingsville, NAS	722516	27.50	97.82	49	14.669	8293	31	36	23	21	19	22	61	20	60	11	360	11	150	102	18	2.0	10.1
Laredo	722520	27.55	99.47	509	14.427	8293	32	36	24	22	20	22	59	20	62	9	320	13	140	106	28	2.2	6.7
Lubbock, Int'l Airport	722670	33.65	101.82	3241	13.054	6193	11	17	30	26	23	30	43	27	44	12	0	14	160	102	4	2.6	5.6
Lubbock, Reese AFB	722675	33.60	102.05	3337	13.008	8293	11	18	25	22	19	25	48	22	44	10	20	11	170	102	6	3.1	4.9
Lufkin	722446	31.23	94.75	289	14.543	6193	23	27	18	16	14	18	44	17	46	6	330	8	230	99	17	3.2	5.3
Marfa	722640	30.37	104.02	4859	12.292	8293	15	19	24	21	18	25	44	22	45	5	360	9	220	97	5	2.3	5.0
McAllen	722506	26.18	98.23	108	14.638	8293	34	40	24	22	20	23	68	21	68	11	350	14	130	106	27	4.3	8.1
Midland/Odessa	722650	31.95	102.18	2861	13.238	6193	17	22	28	25	22	27	50	23	48	9	20	13	180	103	9	2.6	6.9
San Angelo	722630	31.37	100.50	1909	13.709	6193	20	24	26	23	21	25	52	22	51	10	20	11	160	103	13	2.8	6.1
San Antonio, Int'l Airport	722530	29.53	98.47	794	14.279	6193	26	30	22	19	17	23	43	20	45	10	350	10	160	100	19	2.9	5.2
San Antonio, Kelly AFB	722535	29.38	98.58	689	14.333	8293	27	32	19	17	15	21	51	18	52	8	360	8	160	103	22	2.9	6.5
San Antonio, Randolph	722536	29.53	98.28	761	14.296	8293	27	31	19	17	15	20	45	17	48	7	340	7	150	101	20	2.2	6.7
Sanderson	747300	30.17	102.42	2838	13.250	8293	23	28	19	16	13	20	44	17	48	6	360	7	120	102	9	2.9	8.3
Victoria	722550	28.85	96.92	118	14.633	6193	29	33	26	23	21	26	50	23	51	12	360	12	180	99	23	2.5	5.2
Waco	722560	31.62	97.22	509	14.427	6193	22	26	26	23	21	29	38	25	42	13	360	12	180	104	16	2.8	6.4
Wichita Falls, Sheppard	723510	33.98	98.50	1030	14.157	6193	14	19	29	25	23	28	42	25	43	12	360	13	180	107	7	3.4	6.6
UTAH																							
Cedar City	724755	37.70	113.10	5623	11.945	6193	2	8	26	22	20	24	38	21	39	4	140	12	200	97	-6	2.3	8.3
Ogden, Hill AFB	725755	41.12	111.97	4787	12.325	8293	6	11	22	19	17	22	27	19	28	9	110	6	190	96	-1	2.9	6.3
Salt Lake City	725720	40.78	111.97	4226	12.586	6193	6	11	27	23	20	27	42	22	40	7	160	11	340	100	-3	1.9	6.7
VERMONT																							
Burlington	726170	44.47	73.15	341	14.515	6193	-11	-6	23	21	18	24	30	21	27	6	70	11	180	93	-19	2.7	5.6
Montpelier/Barre	726145	44.20	72.57	1165	14.087	8293	-10	-6	21	19	17	22	20	20	20	4	320	9	220	91	-18	3.6	5.9
VIRGINIA																							
Fort Belvoir	724037	38.72	77.18	69	14.659	8293	12	18	18	14	12	19	35	17	34	2	320	6	160	100	2	2.3	7.6
Hampton, Langley AFB	745980	37.08	76.37	10	14.690	8293	21	24	22	19	17	22	41	20	40	10	330	9	240	97	13	3.2	6.1
Lynchburg	724100	37.33	79.20	938	14.204	6193	12	17	19	17	15	21	35	18	35	8	360	9	230	95	5	2.9	5.8
Newport News	723086	37.13	76.50	43	14.673	8293	18	22	19	18	16	20	40	18	41	8	350	10	220	99	11	2.3	4.7
Norfolk	723080	36.90	76.20	30	14.680	6193	20	24	25	22	20	26	40	23	40	12	340	12	230	97	14	2.8	5.4
Oceana, NAS	723075	36.82	76.03	23	14.683	8293	22	25	21	19	17	21	42	19	42	8	310	9	220	98	14	1.8	6.8
Quantico, Mcas	724035	38.50	77.30	13	14.688	8293	16	21	17	14	12	19	36	15	38	6	340	5	230	100	8	3.6	5.9
Richmond	724010	37.50	77.33	177	14.602	6193	14	18	20	18	16	21	40	18	39	7	340	10	230	98	6	2.6	5.8
Roanoke	724110	37.32	79.97	1175	14.082	6193	12	17	23	20	17	27	31	23	32	10	320	10	290	96	4	3.3	5.6

Table 1A Heating and Wind Design Conditions—United States

Station	WHO#	Lat., Deg. N	Long., Deg. W	Elev. ft	StdP, psia	Dates	Heating DB 99.6%	Heating DB 99%	Extreme Wind Speed, mph 1%	2.5%	5%	Cldst Month WS/MDB 0.4% WS	0.4% MDB	1% WS	1% MDB	MWS/MWD to DB 99.6% MWS	99.6% MWD	0.4% MWS	0.4% MWD	Annual Extr. Daily Mean DB Max.	Mean DB Min.	StdD DB Max.	StdD DB Min.
Sterling	724030	38.95	77.45	322	14.525	6193	9	14	22	19	16	25	32	21	31	7	340	10	250	97	-1	3.3	7.0
Washington, National A	724050	38.85	77.03	66	14.661	8293	15	20	23	20	18	24	34	21	35	11	340	11	170	99	8	2.5	6.8
WASHINGTON																							
Bellingham	727976	48.80	122.53	157	14.612	8293	15	21	23	20	18	28	33	23	34	17	40	9	290	87	11	3.1	7.4
Hanford	727840	46.57	119.60	732	14.311	8293	5	12	25	21	18	24	44	19	44	6	20	8	20	105	2	3.1	9.0
Olympia	727920	46.97	122.90	200	14.589	6193	18	23	21	18	16	21	45	19	45	5	180	8	50	94	10	4.0	8.1
Quillayute	727970	47.95	124.55	203	14.588	6193	23	27	33	27	21	41	45	35	45	7	60	9	240	87	19	8.4	6.4
Seattle, Int'l Airport	727930	47.45	122.30	449	14.458	6193	23	28	22	19	17	24	44	21	44	10	10	10	350	92	19	3.6	6.8
Spokane, Fairchild AFB	727855	47.62	117.65	2461	13.435	6193	1	7	27	23	20	28	39	25	38	7	50	9	240	98	-7	3.2	8.7
Stampede Pass	727815	47.28	121.33	3967	12.708	8293	3	10	21	19	16	27	19	22	25	13	90	7	100	84	2	3.2	7.2
Tacoma, McChord AFB	742060	47.13	122.48	322	14.525	8293	18	24	18	15	13	22	45	18	46	2	180	7	20	94	12	2.7	6.8
Walla Walla	727846	46.10	118.28	1204	14.067	8293	4	12	22	19	17	24	49	22	47	6	180	9	300	105	1	3.2	11.7
Wenatchee	727825	47.40	120.20	1243	14.047	8293	3	9	22	19	17	17	36	12	31	3	100	9	280	101	-2	2.5	7.2
Yakima	727810	46.57	120.53	1066	14.138	6193	4	11	24	20	17	23	47	19	43	7	250	7	90	101	-2	3.2	8.5
WEST VIRGINIA																							
Bluefield	724125	37.30	81.20	2858	13.240	8293	5	12	15	13	12	18	34	15	33	6	270	6	290	88	-6	4.0	8.5
Charleston	724140	38.37	81.60	981	14.182	6193	6	11	18	16	14	20	38	18	34	7	250	8	240	94	-2	2.8	6.7
Elkins	724170	38.88	79.85	1998	13.665	6193	-2	5	20	18	16	22	30	19	30	4	280	8	290	88	-12	2.8	5.4
Huntington	724250	38.37	82.55	837	14.257	6193	6	11	19	16	14	20	32	17	32	8	270	8	270	94	-2	5.0	7.6
Martinsburg	724177	39.40	77.98	558	14.402	8293	8	14	21	18	16	23	33	20	34	7	270	9	290	99	-3	4.0	8.3
Morgantown	724176	39.65	79.92	1247	14.045	8293	4	11	18	15	13	19	32	17	33	6	210	8	240	93	-4	3.6	8.6
Parkersburg	724273	39.35	81.43	860	14.245	8293	4	11	18	16	14	20	32	18	29	7	240	8	270	95	-4	3.1	9.2
WISCONSIN																							
Eau Claire	726435	44.87	91.48	906	14.221	6193	-18	-13	22	19	17	21	14	20	13	7	250	13	220	95	-25	3.2	5.7
Green Bay	726450	44.48	88.13	702	14.326	6193	-13	-8	25	22	20	25	19	22	18	10	270	12	200	93	-19	2.8	5.6
La Crosse	726430	43.87	91.25	663	14.347	6193	-14	-8	23	20	18	23	13	21	13	7	310	12	180	97	-21	3.2	6.2
Madison	726410	43.13	89.33	866	14.241	6193	-11	-6	24	21	19	25	16	22	17	8	300	12	230	94	-18	3.2	6.0
Milwaukee	726400	42.95	87.90	692	14.332	6193	-7	-2	28	24	22	28	19	24	20	13	290	15	220	95	-12	3.2	6.7
Wausau	726463	44.93	89.63	1201	14.069	8293	-15	-9	19	17	15	19	16	17	17	7	300	10	200	93	-22	3.1	4.7
WYOMING																							
Big Piney	726710	42.57	110.10	6969	11.353	8293	-22	-15	24	20	17	22	25	19	21	3	60	11	260	87	-33	2.7	8.5
Casper	725690	42.92	106.47	5289	12.096	6193	-13	-5	34	30	27	35	35	32	32	9	260	13	240	97	-22	2.2	8.4
Cheyenne, Warren AFB	725640	41.15	104.82	6142	11.714	6193	-7	0	34	29	26	38	36	33	34	10	290	13	290	92	-15	2.2	7.5
Cody	726700	44.52	109.02	5095	12.184	8293	-14	-7	34	28	23	35	35	30	35	6	40	11	70	95	-20	4.1	9.4
Gillette	726650	44.35	105.53	4035	12.675	8293	-16	-7	28	25	22	30	34	27	33	8	260	11	140	101	-20	5.9	10.1
Lander	725760	42.82	108.73	5558	11.974	6193	-14	-7	23	19	16	25	38	19	37	3	120	10	270	95	-20	2.5	7.8
Rock Springs	725744	41.60	109.07	6759	11.444	6193	-9	-2	28	25	23	32	25	29	24	7	70	13	280	90	-17	2.0	8.0
Sheridan	726660	44.77	106.97	3967	12.708	6193	-14	-8	28	24	20	29	32	23	27	5	280	9	120	99	-22	3.0	6.4
Worland	726665	43.97	107.95	4245	12.577	8293	-22	-13	22	19	16	20	28	17	28	3	210	9	220	103	-30	2.2	10.4

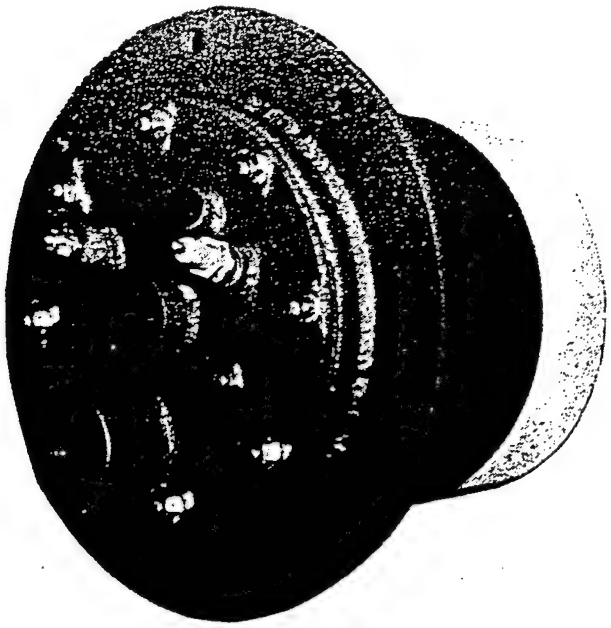
APPENDIX B

VENDOR INFORMATION

SECTION 1

HEATERS

SVG SUPER VELOCITY GAS BURNERS



WARNING

These instructions are intended for use only by experienced, qualified combustion start-up personnel.

TABLE OF CONTENTS

These instructions are intended to serve as guidelines covering the installation, operation, and maintenance of Hauck equipment. While every attempt has been made to ensure completeness, unforeseen or unspecified applications, details, and variations may preclude covering every possible contingency. WARNING: TO PREVENT THE POSSIBILITY OF SERIOUS BODILY INJURY, DO NOT USE OR OPERATE ANY EQUIPMENT OR COMPONENT WITH ANY PARTS REMOVED OR ANY PARTS NOT APPROVED BY THE MANUFACTURER. Should further information be required or desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, contact Hauck Mfg. Co.

A. GENERAL INFORMATION

The SVG Series Super Velocity Gas Burner has been designed for the great number of applications that benefit from high velocity firing. The burner's long life and low maintenance is enhanced by the cool running burner internals and refractory. The SVG performs equally well firing "on ratio" or within a very wide range of excess air or excess fuel operation. Supplemental data sheets SVG-4, 4.1, 4.2, 4.3 and 4.4 list detailed performance information.

SVG standard burners are suitable for preheated air operation to 800F degrees. Higher preheated air temperature versions are available upon request.

Because of their flexibility, SVG burners can be controlled in a variety of ways. Supplemental data sheets SVG-4.5 and 4.6 show three possible control techniques.

B. RECEIVING AND INSPECTION

Upon receipt, check each item to determine that all equipment has been received and to ascertain if there has been any damage in shipment. If installation is delayed and the equipment is to be stored outside, then provide adequate weather protection as dictated by climate and the period of exposure.

C. BURNER CAPACITY TABLE

NOTE

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner.)

SVG BURNER AIR CAPACITIES SCFH

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
SVG-110 Stoichiometric Air Flow	150	365	710	980	1,200	1,390	1,580
SVG-112 Stoichiometric Air Flow	390	640	1,220	1,700	2,200	2,550	2,850
SVG-115 Stoichiometric Air Flow	350	1,000	2,050	2,700	3,500	4,200	4,700
SVG-120 Stoichiometric Air Flow	700	1,700	3,350	4,700	5,900	7,030	7,800
SVG-125 Stoichiometric Air Flow	1,000	2,500	5,260	7,510	9,080	10,500	11,740
SVG-130 Stoichiometric Air Flow	1,300	3,200	6,400	9,090	11,600	13,300	15,000
SVG-135 Stoichiometric Air Flow	1,850	4,070	8,310	11,620	14,330	16,650	18,700
SVG-140 Stoichiometric Air Flow	2,580	5,555	11,110	15,990	19,600	22,720	25,260
SVG-160 Stoichiometric Air Flow	5,810	11,200	24,300	34,980	43,200	50,560	57,280
SVG-180 Stoichiometric Air Flow	10,400	19,500	44,000	63,100	78,500	91,300	104,000

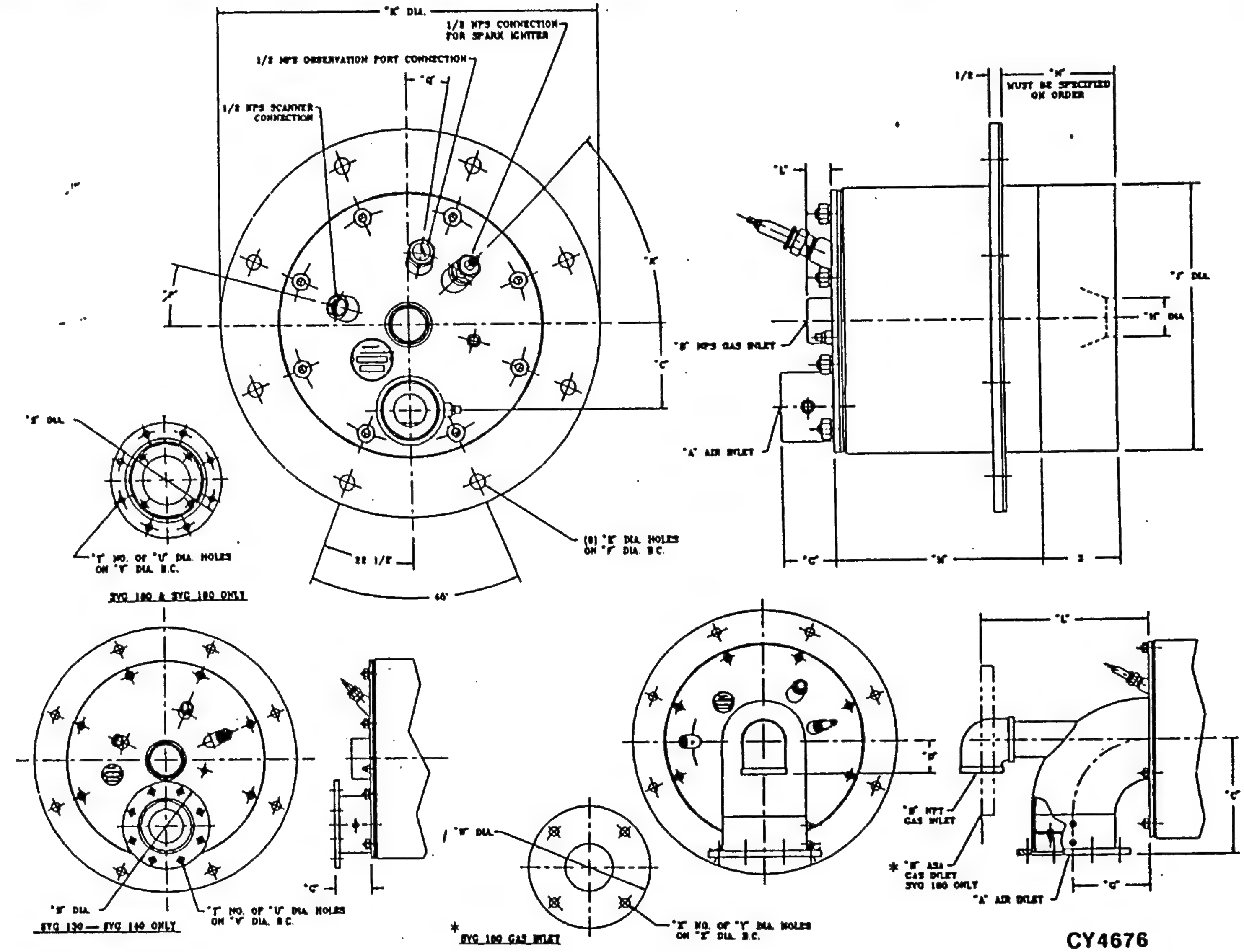
SVG BURNER EXCESS AIR LIMITS

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
SVG-110 % Excess Air	+1,260	+1,290	+4,350	+4,900	+6,170	+7,150	+6,150
SVG-112 % Excess Air	400	1200	1500	+2,000	+3,000	+3,000	+3,000
SVG-115 % Excess Air	850	+2,300	3,000	+4,000	+4,000	+4,000	3,000
SVG-120 % Excess Air	+1,000	+2,000	+2,000	+3,000	+3,500	+4,000	+5,500
SVG-125 % Excess Air	+1,800	+3,300	+7,100	+7,200	+7,500	+7,000	+7,000
SVG-130 % Excess Air	1,500	+5,500	+8,000	+9,000	+9,000	+9,000	+9,000
SVG-135 % Excess Air	+2280	+5,170	+10,670	+10,600	+13,300	+12,800	+10,170
SVG-140 % Excess Air	+3,000	+4,000	+6,000	+8,000	+8,000	+8,000	+8,000
SVG-160 % Excess Air	+2,400	+2,600	+3,500	+3,900	+4,100	+4,200	+3,200
SVG-180 % Excess Air	+1,780	+3,560	+3,390	+2,600	+2,290	+2,350	+2,100

EXCESS AIR LIMITS ARE BASED ON A 1.5 MICRO AMP SIGNAL WHEN THE FLAME MONITOR IS A M/H RA-890G WITH A M/H C7027A SCANNER.

D. DIMENSIONS



CY4676

MODEL NO	A	B	C	D	E	F	G	H	J	K	L	M	N (MIN-MAX)	P	Q	R	S	T	U	V	W	X	Y	Z
SVG 110	1 NPS	3/4	1 5/8	-	1/2	8	2	13/16	6 1/4	8 1/2	5/8	6 1/8	3 - 7 5/8	18"	26"	36"	-	-	-	-	-	-	-	-
SVG 112	1 1/4 NPS	1	2 1/8		5/8	10 1/2	2 1/16	1 1/8	7 3/8	12	15/16	8 15/16	3 - 8 7/16											
SVG 118	1 1/2 NPS		2					1 7/16				9 13/16	3 - 11 3/4											
SVG 120	2 NPS	1 1/4	3 1/2			12 3/4	3 1/8	1 7/8	10 3/4	15 1/2	1	8 3/8	3 - 10 3/8	15"	18"	48"								
SVG 125	2 1/2 NPS		3				3 1/8	2 1/4				11 3/8	3 - 13 3/8											
SVG 130	3 RPM	1 1/2	4 1/8			16 1/4	3 1/4	2 3/4	13	17 3/4		12 1/8	3 - 14 1/4	0"	22 1/2	22 1/2	6	4	7/16	4 3/4				
SVG 135								3 1/16																
SVG 140	4 RPM	2	4 15/16		3/4	19 1/4	3	3 5/8	16	21 1/4	2 1/8	13 1/8	3 - 15 1/4		30"		7	8	19/32	5 15/16				
SVG 160	6 RPM	2 1/2	9 1/4	2 11/16			6	4 5/8			13 3/8					19"	9			7 7/8				
SVG 180	8 RPM	3	10 1/4	-		21 1/4	12	6 1/2	16	23 1/4	16 1/2	15 3/4	3 - 17 1/2	22 1/2	22 1/2	22 1/2	11		9/16	16	7 1/2	4	3/4	8

E. INSTALLATION

1. Furnish an opening in the furnace shell 1/2" larger in diameter than the burner outside diameter. Since SVG burners can fire in any position, they can be installed through the roof, walls or bottom of the furnace.

2. Drawing CW4944 shows the recommended way to install the SVG in a fiber-lined furnace.

3. For an installation in an existing hard refractory wall: make the holes in the hard refractory where the burner tile will be installed, 3 to 6" larger in diameter than the outside diameter of the tile. Pack firmly with a fiber rated for higher temperature than the furnace. It is important to make sure the fiber is well-packed around the burner jacket and that the wall design is such that the temperature at the stainless steel jacket beginning 3" back from the burner tile face, does not go above 1450F degrees. Fiber must be repacked after the first initial firing. Check to prevent any gaps that will allow heat from the furnace to overheat the stainless steel tile support.

4. For installations where it is desired to ram or cast refractory directly against the burner tile, ensure allowance is made for wall refractory movement. Consult Hauck for more information.

5. For installations where furnace temperature is over 2600F, an insulating refractory piece should be attached to the hot face of the burner tile. Consult Hauck for recommendations.

6. The burner should be positioned so that the UV (ultraviolet) flame detector is located above the horizontal centerline to prevent moisture or airborne debris from falling down and blocking the lens. If desired, the UV scanner can be piped with a 1/2" pipe tee between the UV and the SVG burner scanner connection to pipe in cooling and cleaning air. This practice of supplying the scanner tee with cool, clean, dry air is recommended with preheated air or in adverse environments such as dirty combustion air, high ambients, and high moisture areas.

7. Install the burner with at least a 4 pipe diameter length nipple threaded into the air connection of the burner. This will allow the use of the built-in differential orifice taps for $\pm$5% accurate flow measurement. For example, with 1-1/4" diameter pipe use at least a 5" long nipple.

F. OPERATION

Once properly installed, the SVG is ready for operation. The SVG burner is designed to operate with the air and gas pressure best suited to the application.

CAUTION

Initial adjustment and light off should be undertaken only by trained and experienced personnel familiar with combustion systems, control/safety circuitry and overall installation.

G. IGNITION

Ignition of the SVG is by direct spark igniter (included). Consult Hauck if a nozzle mixing pilot is desired. For best ignition, a 5000/6000 volt standard coil type transformer is recommended (see data in sheets SVG-4), although satisfactory ignition is possible with a 1/2 wave "spark-blind" transformer, used in instances where it is necessary not to sight the spark with the UV system during ignition. (See drawing CX4945.)

NOTE

For safety reasons, it is recommended that the burner be ignited under low fire conditions.

NOTE

Like all high velocity burners, the SVG will not ignite from a hot chamber.

WARNING

If standard coil ignition transformer is used, provisions must be made to eliminate the possibility of the ignition spark from falsely satisifying the flame on UV sensor. Hauck designed flame supervisory panels eliminate this possibility.

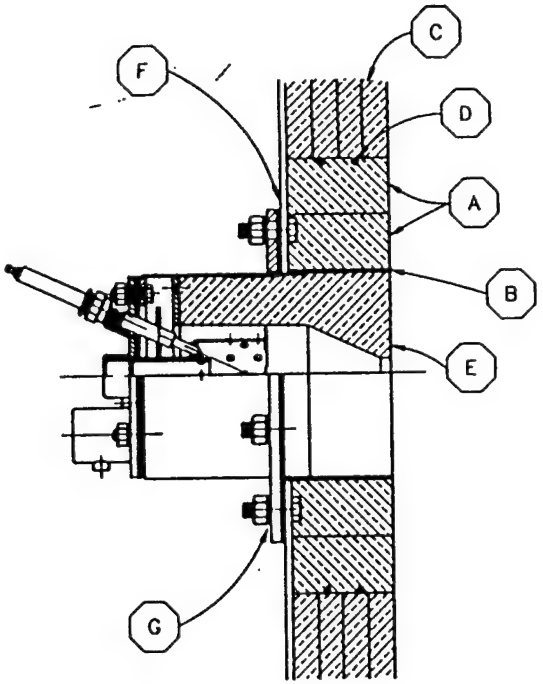
H. MAINTENANCE

The SVG burner has no moving parts requiring any lubrication. However, periodic inspection should be performed to determine if cleaning is required and to inspect the condition of the refractory.

Should it become necessary to remove the electrode for cleaning or inspection the electrode must be inserted to a specific depth for proper ignition. (See drawing CX4945 for proper length.)

NO.	REVISIONS

DWG. NO. CW4944



(A) 2 WRAPS OF 2" FIBER AROUND THE BURNER TILE. THIS FIBER SHOULD BE OF A HIGHER TEMPERATURE RATING THAN THE WALL REFRACTORY (TO PREVENT SHRINKAGE AROUND JACKET)

(B) HIGH TEMPERATURE AIR SET REFRACTORY CEMENT

(C) FIBER BLANKET, BLOCK OR BOARD INSULATION

(D) ROPE OR STRING TO COMPRESS BY 25% THE BURNER TILE FIBER WRAPS. THIS IS INTENDED TO BURN OUT DURING FIRING TO ALLOW FIBER TO EXPAND AND FILL GAPS.

(E) JACKETED SELF-SUPPORTING BURNER TILE

(F) MOUNTING PLATE GASKET

(G) MOUNTING BOLTS WELDED TO THE INSIDE OF THE FURNACE SHELL TO MATCH THE BURNER FLANGE BOLT CIRCLE AND HOLES.

NOTE:
FOR INSTALLATIONS WITH FURNACE TEMPERATURES TO 2600°F

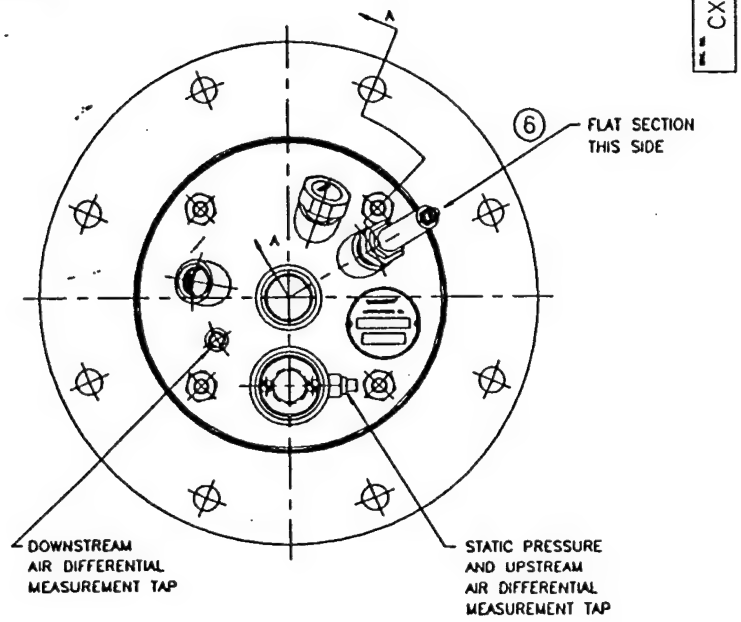
MAT'L	PROCESS CODE	DRN. TP 5-13 91
		CHK.
		APP.
TITLE: BURNER TILE INSTALLATION FOR FURNACES LINED WITH CERAMIC FIBER INSULATION (SVG & SNMG)		ENG.
		SALES
		PROD.

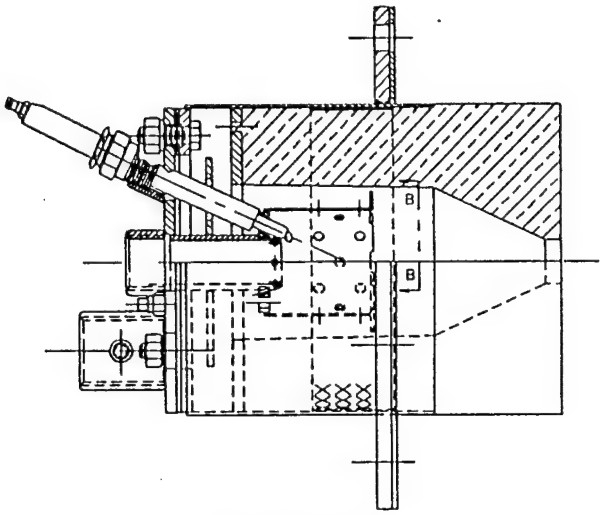
HAUCK
LEBANON, PA.

SCALE	DWG. SIZE	DWG NO.	SHT NO.	OF
		CW4944		

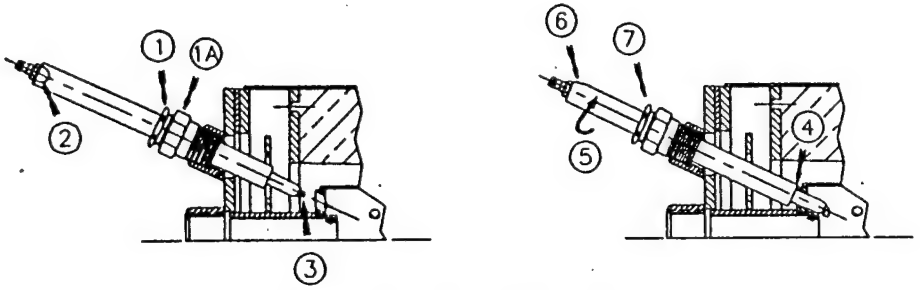
NO	REVISIONS
1	11-92-1 DLS 1-24-92
2	57-92-1 JZ 3-27-92
3	220-92-1 BSA 11-18-92
4	229-92-1 TP 12-2-92

CX4945





SECTION "A-A"



IGNITER INSTALLATION INSTRUCTIONS

1. LOOSEN SPARKPLUG BUSHING SO INSULATOR CAN SLIDE FREELY
1A. TIGHTEN SPARKPLUG BUSHING TO SECURE IGNITER
2. ROTATE SPARK IGNITER SO THAT FLAT ON THE INSULATOR IS AS SHOWN
3. BENT ELECTRODE TIP SHOULD CLEAR END OF GAS TUBE AS IGNITER IS INSERTED
4. BACKPLATE OF BURNER CUP STOPS INSERTION
5. ROTATE IGNITER 90° COUNTERCLOCKWISE
6. INSULATOR FLAT MUST FACE OUTWARD
7. SNUG CERAMIC BUSHING TO SECURE IGNITER TUBE-CAUTION: OVERTIGHTENING BUSHING ON CERAMIC CAN CRACK INSULATOR.
8. REVERSE PROCEDURE TO REMOVE IGNITER ASSEMBLY

MFG.	PROCESS CODE	DRN. TP	8-13-91
		CHK.	
		APP.	
SIZE	BURNER INSTALLATION, IGNITER POSITIONING & PRESSURE TAP LOCATION (SVG & SNMG)	ENG.	
		SALES	
		PROJ.	

LENNOX LEBANON, PA.

SCALE | DRW. SIZE | DRAWING CONTROL NO. CX4945

SVG SUPER VELOCITY GAS BURNERS

SVG BURNER AIR CAPACITIES SCFH

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
SVG-110 Stoichiometric Air Flow	150	365	710	980	1,200	1,390	1,580
SVG-112 Stoichiometric Air Flow	390	640	1,220	1,700	2,200	2,550	2,850
SVG-115 Stoichiometric Air Flow	350	1,000	2,050	2,700	3,500	4,200	4,700
SVG-120 Stoichiometric Air Flow	700	1,700	3,350	4,700	5,900	7,030	7,800
SVG-125 Stoichiometric Air Flow	1,000	2,500	5,260	7,510	9,080	10,500	11,740
SVG-130 Stoichiometric Air Flow	1,300	3,200	6,400	9,090	11,600	13,300	15,000
SVG-135 Stoichiometric Air Flow	1,850	4,070	8,310	11,620	14,330	16,650	18,700
SVG-140 Stoichiometric Air Flow	2,580	5,555	11,110	15,990	19,600	22,720	25,260
SVG-160 Stoichiometric Air Flow	5,810	11,200	24,300	34,980	43,200	50,560	57,280
SVG-180 Stoichiometric Air Flow	10,400	19,500	44,000	63,100	78,500	91,300	104,000

SVG BURNER EXCESS AIR LIMITS

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
SVG-110 % Excess Air	+1,260	+1,290	+4,350	+4,900	+6,170	+7,150	+6,150
SVG-112 % Excess Air	400	1200	1500	+2,000	+3,000	+3,000	+3,000
SVG-115 % Excess Air	850	+2,300	3,000	+4,000	+4,000	+4,000	3,000
SVG-120 % Excess Air	+1,000	+2,000	+2,000	+3,000	+3,500	+4,000	+5,500
SVG-125 % Excess Air	+1,800	+3,300	+7,100	+7,200	+7,500	+7,000	+7,000
SVG-130 % Excess Air	1,500	+5,500	+8,000	+9,000	+9,000	+9,000	+9,000
SVG-135 % Excess Air	+2280	+5,170	+10,670	+10,600	+13,300	+12,800	+10,170
SVG-140 % Excess Air	+3,000	+4,000	+6,000	+8,000	+8,000	+8,000	+8,000
SVG-160 % Excess Air	+2,400	+2,600	+3,500	+3,900	+4,100	+4,200	+3,200
SVG-180 % Excess Air	+1,780	+3,560	+3,390	+2,600	+2,290	+2,350	+2,100

EXCESS AIR LIMITS ARE BASED ON A 1.5 MICRO AMP SIGNAL WHEN THE FLAME MONITOR IS A M/H RA-890G WITH A M/H C7027A SCANNER.

(OVER)

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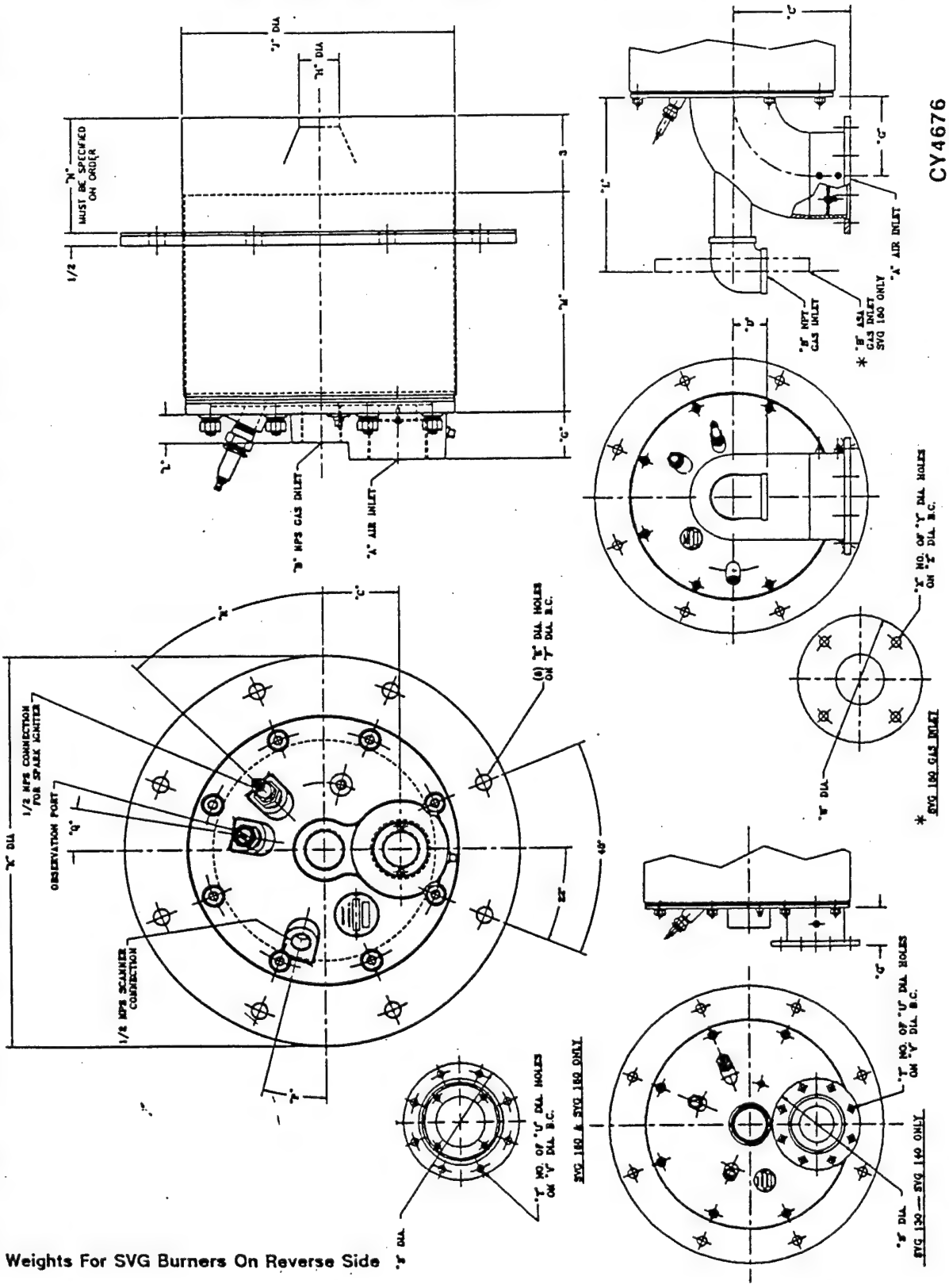
6/93

SVG BURNER FLAME LENGTHS

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
SVG-110 Stoichiometric Flame	6"	7"	7"	7"	7"	7"	8"
SVG-112 Stoichiometric Flame	9"	12"	13"	16"	20"	22"	22"
SVG-115 Stoichiometric Flame	12"	14"	15"	19"	22"	24"	30"
SVG-120 Stoichiometric Flame	16"	18"	20"	22"	24"	25"	26"
SVG-125 Stoichiometric Flame	20"	20"	24"	28"	30"	36"	38"
SVG-130 Stoichiometric Flame	32"	32"	36"	42"	42"	48"	48"
SVG-135 Stoichiometric Flame	3'	3'	4'	4'	4'	5'	5'
SVG-140 Stoichiometric Flame	3'	4'	4'	4'	5'	5'	6'
SVG-160 Stoichiometric Flame	4'	6'	7'	8'	8.5'	9'	9.5'
SVG-180 Stoichiometric Flame	5'	8'	9'	9'	9'	10'	10'

SVG SUPER VELOCITY GAS BURNERS



CY4676

MODEL NO.	A	B	C	D	E	F	G	H	J	K	L	M (MIN-MAX)	N	P	Q	R	S	T	U	V	W	X	Y	Z
SVG 100	1 NPS	3/4	1 1/8		1/2	8	1 3/32	13/16	6 1/4	8 1/2	7/16	3 - 9 6/8	8 5/8	10"	22 1/2"	30"	7	8	7/16	4 3/4	6 10/16	-	-	-
SVG 100 DVD	1 NPS	3/4	1 1/8		1/2	8	1 3/32	13/16	6 1/4	8 1/2	7/16	3 - 9 6/8	8 5/8	10"	22 1/2"	30"	7	8	7/16	4 3/4	7 7/8	-	-	-
SVG 125	1 NPS	1	2	-	5/8	10	1 3/16	1 1/16	7 3/8	12	1	3 - 10 3/4	10	15"	25"	45"	8	-	15/32	-	-	-	-	-
SVG 125 DVD	1 NPS	1	2	-	5/8	10	1 3/16	1 1/16	7 3/8	12	1	3 - 10 3/4	10	15"	25"	45"	8	-	15/32	-	-	-	-	-
SVG 150	2 NPS	1 1/4	3	-	5/8	13 3/4	1 13/16	1 7/16	10 3/4	15 1/2	1 1/8	3 - 11 13/16	11 9/16	15"	22 1/2"	45"	8	-	9/16	-	-	-	-	-
SVG 150 DVD	2 NPS	1 1/4	3	-	5/8	13 3/4	1 13/16	1 7/16	10 3/4	15 1/2	1 1/8	3 - 11 13/16	11 9/16	15"	22 1/2"	45"	8	-	9/16	-	-	-	-	-
SVG 200	2 NPS	1 1/2	3	11/16	3/4	16 1/4	2 3/16	1 7/8	12 3/4	17 3/4	1 1/8	3 - 13 13/16	12 1/8	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 200 DVD	2 NPS	1 1/2	3	11/16	3/4	16 1/4	2 3/16	1 7/8	12 3/4	17 3/4	1 1/8	3 - 13 13/16	12 1/8	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 250	2 NPS	1 1/2	3	11/16	3/4	16 1/4	2 3/16	1 7/8	12 3/4	17 3/4	1 1/8	3 - 13 13/16	12 1/8	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 250 DVD	2 NPS	1 1/2	3	11/16	3/4	16 1/4	2 3/16	1 7/8	12 3/4	17 3/4	1 1/8	3 - 13 13/16	12 1/8	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 300	3 NPS	2	4 1/8	2 11/16	3/4	21 1/4	3 1/16	2 1/16	16 3/4	22 1/4	1 1/2	3 - 15 9/16	15 3/16	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 300 DVD	3 NPS	2	4 1/8	2 11/16	3/4	21 1/4	3 1/16	2 1/16	16 3/4	22 1/4	1 1/2	3 - 15 9/16	15 3/16	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 350	3 NPS	2	4 1/8	2 11/16	3/4	21 1/4	3 1/16	2 1/16	16 3/4	22 1/4	1 1/2	3 - 15 9/16	15 3/16	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 350 DVD	3 NPS	2	4 1/8	2 11/16	3/4	21 1/4	3 1/16	2 1/16	16 3/4	22 1/4	1 1/2	3 - 15 9/16	15 3/16	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-
SVG 400	3 NPS	2	4 1/8	2 11/16	3/4	21 1/4	3 1/16	2 1/16	16 3/4	22 1/4	1 1/2	3 - 15 9/16	15 3/16	0"	22 1/2"	30"	7	8	9/16	4 3/4	7 7/8	-	-	-

Weights For SVG Burners On Reverse Side

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10/95

Weights For SVG Gas Burners

MODEL	WEIGHT POUNDS
110	25*
112	40
115	45
120	85
125	96
130	157
135	187*
140	242
160	250*
180	419*

*Estimated

SVG SUPER VELOCITY GAS BURNERS

BURNER MODEL SVG 110

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						1,445	
70°F AIR Capacity SCFH stoichiometric	150	365	710	980	1,200	1,390	1,580
Delta P "wc Air Orifice stoichiometric	0.2	1.2	4.6	9.5	13.9	19.1	25.2
Gas (Tile) Pressure "wc stoichiometric	0.1	0.7	2.3	4.4	7.0	8.9	9.7
Maximum % Excess Air	+1,260	+1,290	+4,350	+4,900	+6,170	+7,150	+6,150
#) Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	7"	7"	7"	7"	7"	7"	8"
Flame Dia.,stoichiometric	1.0"	1.0"	1.0"	1.0"	1.0"	1.0"	1.3"
Ignition SCFH N.G. Gas Max.	* RATIO+	* RATIO+	* RATIO+	* RATIO+	* RATIO+	* RATIO+	* RATIO+
-Ignition SCFH N.G. Gas Min.	- 3	- 3	- 3	- 4	- 4	- 4	- 4

*) For safe & smooth ignition a lean air/fuel ratio is recommended

-) Data is for 5000V transformer, a 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods .
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

(OVER)

BURNER MODEL SVG 112

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						2,680	
70°F AIR Capacity SCFH stoichiometric	390	640	1,220	1,700	2,200	2,550	2,800
Delta P "wc Air Orifice stoichiometric	0.2	1.2	4.7	10.0	16.0	22.0	26.0
Gas (Tile) Pressure "wc stoichiometric	0.1	0.5	2.1	3.6	4.7	6.1	7.1
Maximum % Excess Air	400	1200	1500	+2,000	+3,000	+3,000	+3,000
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	9"	12"	13"	16"	20"	22"	22"
Flame Dia.,stoichiometric	2"	2"	3"	4"	5"	5"	5"
Ignition SCFH N.G. Gas Max.	* 10	* 15	* 20	* 35	* 40	* 50	* 60
Ignition SCFH N.G. Gas Min.	~ 6	~ 6	~ 7	~ 8	~ 8	~ 10	~ 10

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

SVG SUPER VELOCITY GAS BURNERS

BURNER MODEL SVG 115

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						4,890	
70°F AIR Capacity SCFH stoichiometric	350	1,000	2,050	2,700	3,500	4,200	4,700
Delta P "wc Air Orifice stoichiometric	0.2	1.1	4.1	7.5	11.6	16.3	21.0
Gas (Tile) Pressure "wc stoichiometric	0.0	0.7	2.8	5.3	8.4	11.5	13.9
Maximum % Excess Air	850	+2,300	3,000	+4,000	+4,000	+4,000	3,000
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	12"	14"	15"	19"	22"	24"	30"
Flame Dia.,stoichiometric	2"	2"	2.5"	2.5"	3"	3"	3"
Ignition SCFH N.G. Gas Max.	* 130	* 160	* 250	* 265	* 270	* 350	* 400
Ignition SCFH N.G. Gas Min.	~ 5	~ 5	~ 7	~ 7	~ 9	~ 9	~ 9

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

(OVER)

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10/94

BURNER MODEL SVG 120

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						7,400	
70°F AIR Capacity SCFH stoichiometric	700	1,700	3,350	4,700	5,900	7,030	7,800
Delta P "wc Air Orifice stoichiometric		1.2	4.9	9.7	14.6	20.5	25.5
Gas (Tile) Pressure "wc stoichiometric		0.4	1.7	3.8	5.6	6.2	7.8
Maximum % Excess Air	+1,000	+2,000	+2,000	+3,000	+3,500	+4,000	+5,500
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	20
Flame Length,stoichiometric	16"	18"	20"	22"	24"	25"	26"
Flame Dia.,stoichiometric	4"	4"	4"	5"	6"	6"	7"
Ignition SCFH N.G. Gas Max.	* 70	* 170	* 320	* 470	* 600	* 715	* 790
Ignition SCFH N.G. Gas Min.	~ 7	~ 10	~ 15	~ 20	~ 25	~ 30	~ 35

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

SVG SUPER VELOCITY GAS BURNERS

BURNER MODEL SVG 125

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						12,000	
70°F AIR Capacity SCFH stoichiometric	900	2,715	5,260	7,510	9,080	10,500	11,740
Delta P "wc Air Orifice stoichiometric	0.1	0.9	3.9	7.7	11.5	15.3	19.2
Gas (Tile) Pressure "wc stoichiometric	0.1	0.5	2.7	5.1	7.7	10.5	13.2
Maximum % Excess Air	+1,800	+3,300	+7,100	+7,200	+7,500	+7,000	+7,000
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	20"	20"	24"	28"	30"	36"	38"
Flame Dia.,stoichiometric	3"	4"	4"	5"	5"	6"	6"
Ignition SCFH N.G. Gas Max.	* 200	* 400	* 700	* 900	* 1,100	* 1,300	* 1,500
Ignition SCFH N.G. Gas Min.	~ 7	~ 7	~ 9	~ 15	~ 33	~ 40	~ 60

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

(OVER)

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BURNER MODEL SVG 130

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						15,000	
70°F AIR Capacity SCFH stoichiometric	1,300	3,200	6,400	9,090	11,600	13,300	15,000
Delta P "wc Air Orifice stoichiometric	0.2	2.5	5.1	10.0	15.2	20.5	25.0
Gas (Tile) Pressure "wc stoichiometric	0.1	1.5	2.1	4.1	6.3	8.3	10.5
Maximum % Excess Air	1,500	+5,500	+8,000	+9,000	+9,000	+9,000	+9,000
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	32"	32"	36"	42"	42"	48"	48"
Flame Dia.,stoichiometric	6"	4"	5"	7"	7"	7"	7"
Ignition SCFH N.G. Gas Max.	* 150	* 400	* 750	* 1,000	* 500	* 500	* 500
Ignition SCFH N.G. Gas Min.	~ 8	~ 8	~ 8	~ 15	~ 20	~ 30	~ 40

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

SVG SUPER VELOCITY GAS BURNERS

BURNER MODEL SVG 135

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						18,350	
70°F AIR Capacity SCFH stoichiometric	1,850	4,070	8,310	11,620	14,330	16,650	18,700
Delta P "wc Air Orifice stoichiometric	0.2	1.1	5.0	9.9	14.8	19.8	24.6
Gas (Tile) Pressure "wc stoichiometric	0.1	0.3	1.6	3.5	5.3	7.2	8.9
Maximum % Excess Air-UV Scanner	+2280	+5,170	+10,670	+10,600	+13,300	+12,800	+10,170
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	3'	3'	4'	4'	4'	5'	5'
Flame Dia.,stoichiometric	8"	8"	9.0"	9.0"	10"	10"	10"
Ignition SCFH N.G. Gas Max.	* 300	* 700	* 1,900	* 2,000	* 2,500	* 3,000	* 3,200
Ignition SCFH N.G. Gas Min.	- 8	- 11	- 16	- 20	- 22	- 36	- 39

*) For safe & smooth ignition a lean air/fuel ratio is recommended

-) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

BURNER MODEL SVG 140

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						25,000	
70°F AIR Capacity SCFH stoichiometric	2,580	5,555	11,110	15,990	19,800	22,720	25,280
Delta P "wc Air Orifice stoichiometric	0.2	2.2	4.7	9.4	13.8	18.5	23.4
Gas (Tile) Pressure "wc stoichiometric	0.1	0.6	2.3	4.7	7.1	9.5	11.6
Maximum % Excess Air	+3,000	+4,000	+6,000	+8,000	+8,000	+8,000	+8,000
Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	36"	40"	48"	48"	54"	62"	66"
Flame Dia.,stoichiometric	10"	11"	11"	10"	12"	12"	12"
Ignition SCFH N.G. Gas Max.	* 300	* 700	* 1,900	* 2,000	* 2,500	* 3,000	* 3,200
Ignition SCFH N.G. Gas Min.	~ 25	~ 25	~ 43	~ 68	~ 88	~ 110	~ 160

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer. A 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods.
Bleed air in gas line is recommended

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

SVG SUPER VELOCITY GAS BURNERS

BURNER MODEL SVG 160

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						55,800	
70°F AIR Capacity SCFH stoichiometric	5,810	11,200	24,300	34,980	43,200	50,560	57,280
Delta P "wc Air Orifice stoichiometric	0.2	0.8	3.5	7.1	11.0	14.5	18.2
Gas (Tile) Pressure "wc stoichiometric	0.1	0.5	2.0	3.8	6.0	7.8	9.5
Maximum % Excess Air	+2,400	+2,600	+3,500	+3,900	+4,100	+4,200	+3,200
#) Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	4'	6'	7'	8'	8.5'	9'	9.5'
Flame Dia.,stoichiometric	10"	10"	12"	14"	16"	17"	17"
Ignition SCFH N.G. Gas Max.	* na	* na	* na	* na	* na	* na	* na
~Ignition SCFH N.G. Gas Min.	~ 23	~ 32	~ 81	~ 124	~ 202	~ 332	~ 437

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer, a 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods .

Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

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BURNER MODEL SVG 180

MAIN AIR PRESSURE OSI AT BURNER INLET TAP

	0.17 OSI	1 OSI	4 OSI	8 OSI	12 OSI	16 OSI	20 OSI
70°F AIR Capacity SCFH not firing						98,750	
70°F AIR Capacity SCFH stoichiometric	10,400	19,500	44,000	63,100	78,500	91,300	104,000
Delta P "wc Air Orifice stoichiometric	0.1	0.6	2.3	4.6	6.8	9.0	11.4
Gas (Tile) Pressure "wc stoichiometric	0.1	0.3	1.4	3.0	4.5	5.8	6.9
Maximum % Excess Air	+1,780	+3,560	+3,390	+2,600	+2,290	+2,350	+2,100
#) Maximum % Excess Fuel	# +30	+30	+30	+30	+30	+30	+30
Flame Length,stoichiometric	5'	8'	9'	9'	9'	10'	10'
Flame Dia.,stoichiometric	15"	15"	17"	17"	17"	17"	17"
Ignition SCFH N.G. Gas Max.	* na	* na	* na	* na	* na	* na	* na
~Ignition SCFH N.G. Gas Min.	~ 56	~ 56	~ 147	~ 267	~ 427	~ 633	~ 1,413

*) For safe & smooth ignition a lean air/fuel ratio is recommended

~) Data is for 5000V transformer, a 1/2 wave ("spark blind") transformer requires higher gas flow

#) At max. excess fuel carbon could form if fired for extended periods .

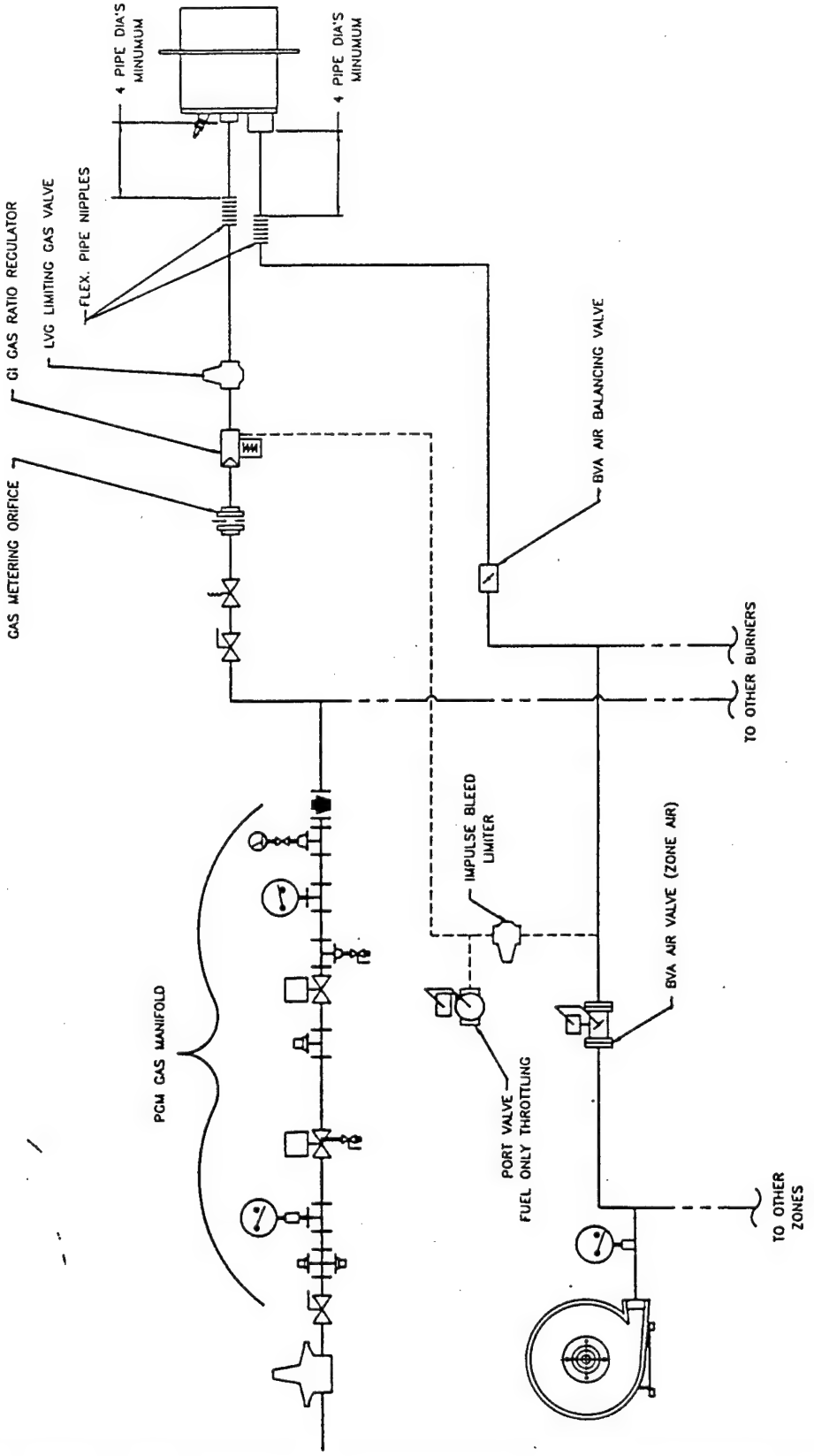
Limits listed above are for natural gas; for other fuel gas limits may be different

Note:

If application requires igniting an SVG burner with fixed air over 4 osi, Hauck requires the use of a spark transformer. (An electronic spark generator will not provide sufficient spark energy to ignite the burner).

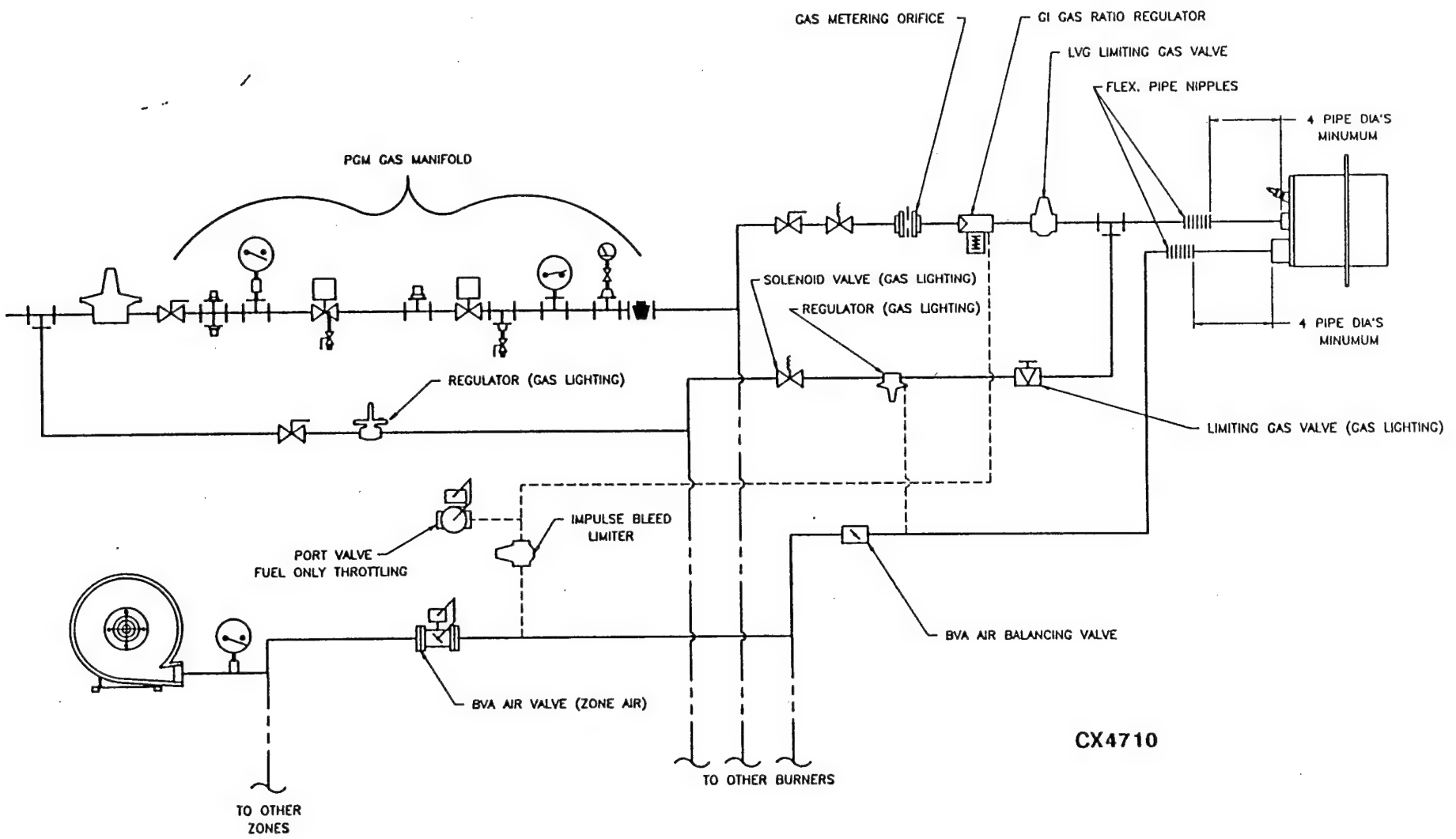
SVG SUPER VELOCITY GAS BURNERS

SYSTEM SCHEMATIC
BURNER PIPING
SVG RATIO & EXCESS AIR
WITH DIRECT SPARK



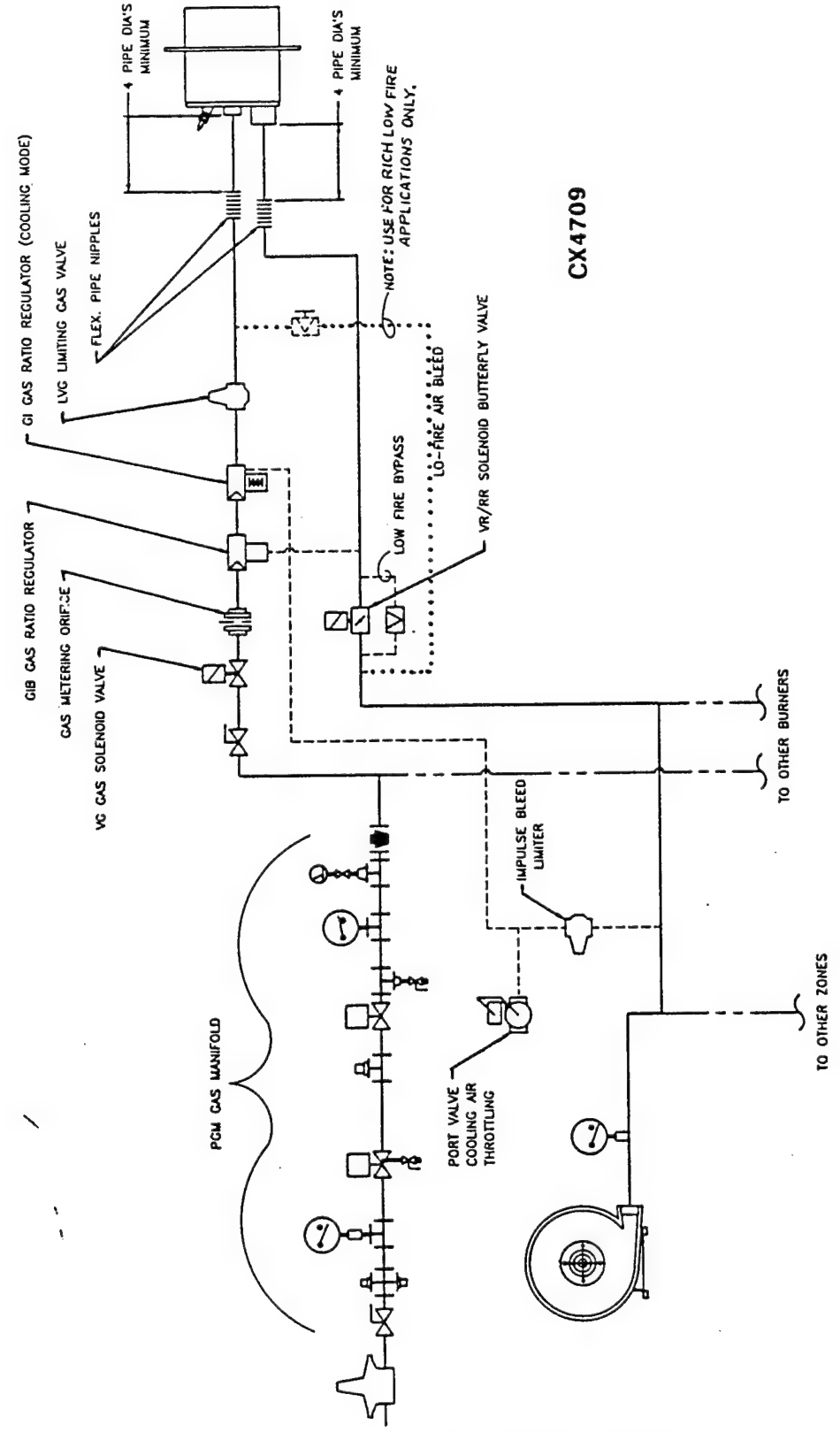
CX4916

SYSTEM SCHEMATIC
BURNER PIPING
SVG RATIO & EXCESS AIR
WITH DIRECT SPARK &
MAX. XSA TURNDOWN



SVG SUPER VELOCITY GAS BURNERS

SYSTEM SCHEMATIC
BURNER PIPING
SVG PULSE HEAT/COOL SYSTEM



SVG SUPER VELOCITY GAS BURNERS

GENERAL INFORMATION

Fuel only control takes advantage of the SVG burner's wide fuel and air ratio limits.

Ratio or stoichiometric firing is enhanced with the burner's high turndown ratio, such as a turndown of air pressure at the burner from 16 osi at high fire to a minimum low fire of .17 osi. Of course, with less than stoichiometric gas flow at the minimum air pressure, thermal turndown can be much higher.

For applications requiring extended firing time while operating rich at minimum air pressure, a small amount of (constant pressure) combustion air is injected into the gas line at each burner. This air bleed is not required if the burner is operated lean at minimum air flow.

Maximum recommended air pressure is 20 osig. Standard burners are suitable for 800F preheated air with a 6:1 air turndown at 16 osi.

Air flow can be measured within 5% across an orifice built into the burner. To use the orifice correctly, a straight pipe nipple of a length at least equal to 4 pipe diameters must be threaded into the burner.

Gas pressure at the inlet to the burner is approximately 40% of the air pressure required for stoichiometric ratio. For gas measurements, separate gas metering devices must be used.

Like all high velocity burners, the SVG can not be ignited with a manual torch nor will it reignite off a hot furnace.

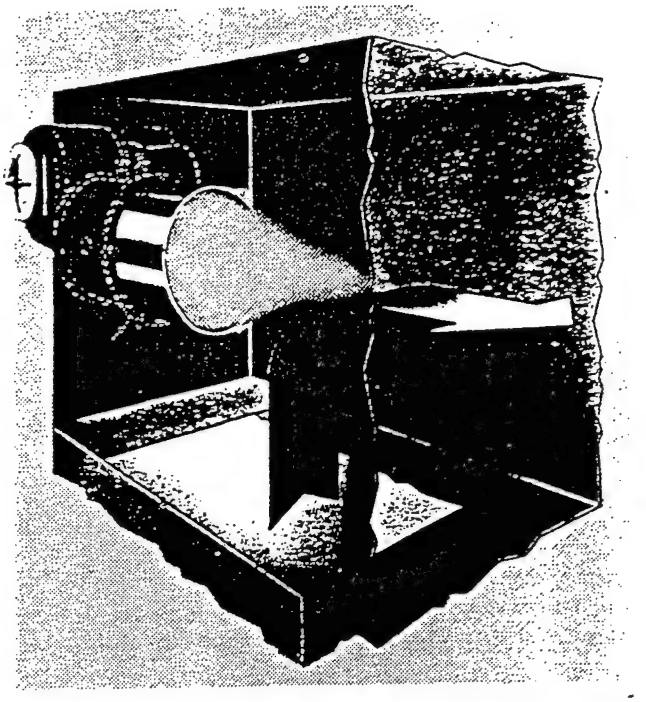
In the interest of safety, Hauck strongly recommends flame supervision. A 1/2" NPT connection on the burner backplate accomodates UV flame detectors.

North American
Mfg. Co.
Cleveland, OH 44105 USA

ZEPHYR INTEGRAL BLOWER
GAS BURNERS

BULLETIN 4988
10-88

AIR HEATERS • DRYERS • OVENS



4988 Zephyr Burners are ideal for lower temperature applications, up to 1200 F. Standard burners include an integral combustion air blower, pilot, spark igniter, flame rod, and other features that simplify installation and operation. Zephyr Burners have unmatched flexibility and adaptability to a wide variety of conditions:

Low or variable air velocities do not affect burner performance or stability.

High Turndown. 50 to 1 (and higher) by control of gas only. Advantages of high turndown include: (a) better oven temperature uniformity, (b) simplified burner selection because each burner can operate over a wide range of firing rates, and (c) simplified control circuitry. During process interruptions, burner can idle at low rates, eliminating need for shutdown and time-consuming restarts.

Low Gas Pressure Requirement. Only 3"wc above duct pressure at the burner. If burner is on suction side of recirculating fan, even less pressure is needed.

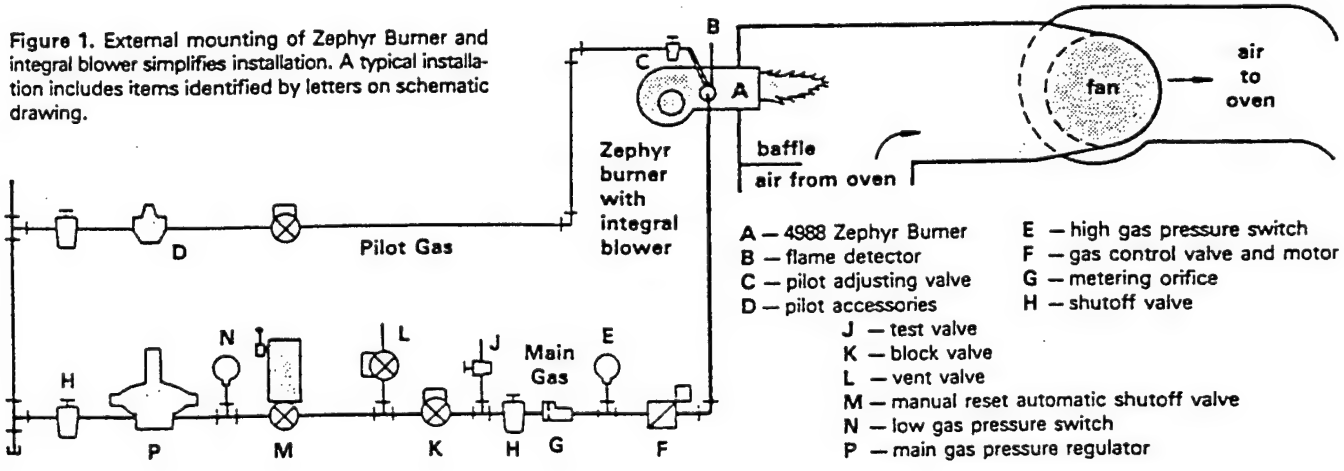
Variety of Mounting Arrangements. Any position inside duct or on exterior duct wall, as long as motor shaft is horizontal. When wall-mounted, burner protrudes into duct, preventing overheating of adjacent oven walls.

High Strength Construction. Burner housing is sturdy aluminized steel, rigidly assembled and braced to resist distortion and warping at operating temperatures. All parts in contact with flame are stainless steel. Check with North American for applications above 1200 F.

Zephyr Burners have nominal ratings of 1, 2.5, 4, 6, and 9 million Btu/hr. Three combustion air fan arrangements are available, all with the same burner body:

- 4988- -L with low pressure blower: for installation on suction side of a recirculating fan.
- 4988- -H (-1000 through -6000 only) with higher pressure blower: for use on discharge side of recirculating fan (where duct pressure is no more than 3.5"wc cold).
- 4988- -R with no integral blower: for remote blower installations or those requiring blowers different from standard.

Figure 1. External mounting of Zephyr Burner and integral blower simplifies installation. A typical installation includes items identified by letters on schematic drawing.



A — 4988 Zephyr Burner
B — flame detector
C — pilot adjusting valve
D — pilot accessories
E — high gas pressure switch
F — gas control valve and motor
G — metering orifice
H — shutoff valve
J — test valve
K — block valve
L — vent valve
M — manual reset automatic shutoff valve
N — low gas pressure switch
P — main gas pressure regulator

Flame Supervision and Ignition. All Zephyrs can be used with ultraviolet flame detection systems. Flame rods are suitable for all but the 4988-9000. Burners include spark plug and 5′ of ignition cable. An ignition transformer with 6000 volt secondary is required. Pressure taps are provided in the blower discharge--a convenience for systems requiring a differential air pressure switch to prove blower operation.

Installation. Zephyrs can be installed in any horizontal or vertical duct (but motor shaft must be horizontal). To promote even heating of duct air stream, position burner in a section of duct where air flow is reasonably straight. Avoid sharp turns, obstructions, or dampers immediately upstream of burner.

Installation can be made downstream of a circulation fan, but Zephyr blower and connection duct work have to be selected carefully to overcome oven pressure (unless Zephyr blower is installed within the duct).

If duct air temperature is over 100 F, blower must be mounted outside duct. Dimensions of interconnecting air duct are important: check with factory for recommended dimensions. Provide access doors for inspection and servicing burner. Sight ports or windows are necessary for observation of flame.

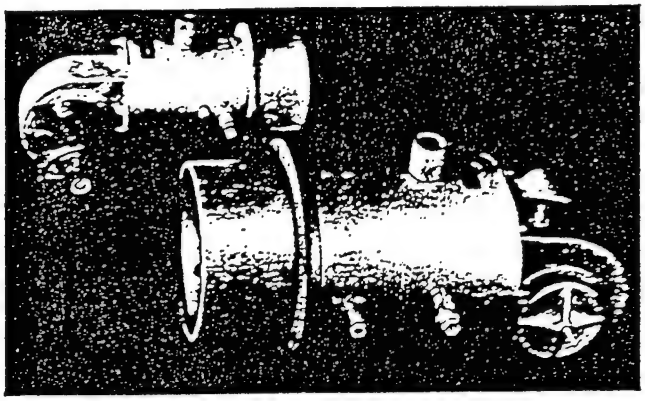


Figure 2. Two of the five sizes of 4988 ZEPHYR Gas Burners with integral blower. Construction is simple and durable. Installation is easy. There is convenient access to all components.

Fuels. Zephyr Burners are designed for natural gas. They will burn propane (containing no propylene) or butane (containing no butylene); but for straight vapor, internal modification of 4988-1000 through -6000 is required--when ordering, specify fuel. 4988-9000-L Burners require no modification.

With propane or butane, carbon tends to form on flame rods, so use scanner type flame detectors.

Caution. Multiple burner installations must include a main gas shutoff valve--either manual or electric--for each burner. This valve must be shut during pilot (low fire) ignition.

Table 1. CAPACITIES

"L" blowers develop 1 "wc air pressure at burner.

"H" models develop 4.5 "wc at burner.

Motors are 230-460/3/60, except 115/1/60 is an option for -1000 burners.

Burner designation	millions of Btu/hr	motor hp & rpm "L"	motor hp & rpm "H"	blower volume cfh @ 1 "wc ΔP
4988-1000	1.0	½-3450	½-3450	16 200
4988-2500	2.5	1 -3450	2 -3450	40 800
4988-4000	4.0	1 -1725	3 -3450	64 800
4988-6000	6.0	1½-1725	3 -3450	96 000
4988-9000	9.0	3 -3450	—	123 000

Temperature Effect. Burner performance may change as oven air temperature rises from start-up to operating levels because changing air density affects pressure from oven circulating fan. As oven pressure changes, air pressure drop across Zephyr burner also changes, thereby modifying air volume passing through burner. Effect is most marked at elevated temperatures, but it should be checked at all temperatures. Table 2 indicates how fan pressure changes with temperature. Altitude also affects blower capacity and pressure. Above 3300 feet, special motors are usually required--consult North American.

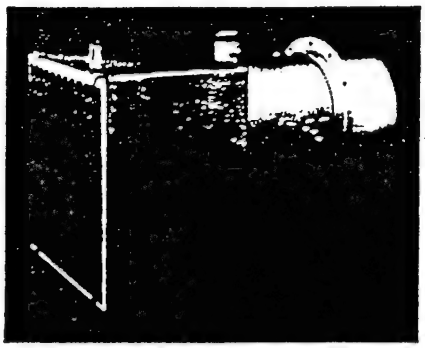
When selecting burners, blowers, and fans, make sure burner pressure drop is within the stability ranges of Table 3 at all temperatures and all firing rates.

Table 2. Effect of air temperature on pressure developed by a recirculating fan.

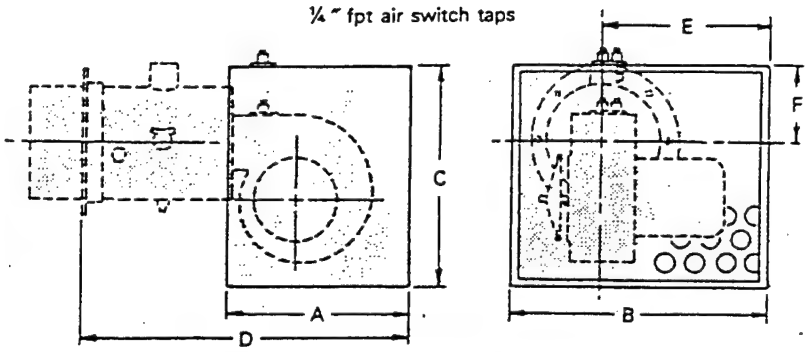
temperature	factor	temperature	factor
60 F	1.00	600 F	0.49
100 F	0.93	700 F	0.45
150 F	0.85	800 F	0.42
200 F	0.79	900 F	0.38
300 F	0.68	1000 F	0.36
400 F	0.60	1100 F	0.33
500 F	0.54	1200 F	0.31

Table 3. Flame stability ranges.

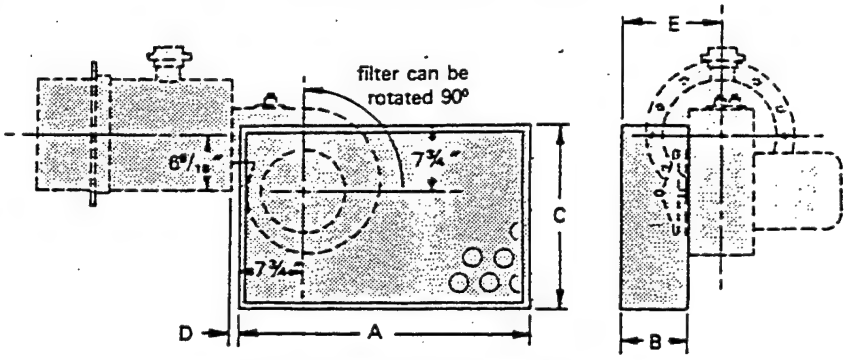
4988- -L, H, or R	air pressure drop, "wc minimum	maximum
1000	0.25	4.0
2500	0.50	3.0
4000	0.25	3.0
6000	0.25	2.5
9000	0.50	2.5



Filter Assemblies, optional for 4988 Burners, use inexpensive throwaway panel filters to clean air entering Zephyr blowers. On 4988-1000, -2500, -4000, and -6000-L Burners, filter housing completely encloses blower and motor; air switch taps and a conduit knockout on the housing permit connections to blower and motor. Filters for -6000-H and -9000-L Burners attach to blower inlet. Filters are shipped loose for field installation.



Filter for 4988-1000,-2500,-4000, and-6000-L



Filter for 4988-6000-H and -9000-L

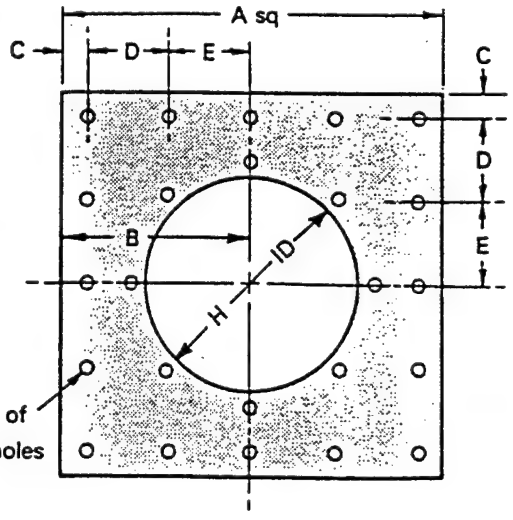
filter assembly for 4988	dimensions in inches A	B	C	D	E	F	no. of filter panels	filter size	filter elements only (panels)
4-5676-1 filter assembly for -1000-L & -H	13⅛	20¼	20¼	23¾	13	6	1	20" × 20" × 2"	R260-3241
4-5683-1 filter assembly for -2500-L & -H	17⅛	22¼	20¼	32¾	15	7	1	20" × 20" × 2"	R260-3241
4-5687-1 filter assembly for -4000-L & -H and -6000-L	20½	25½	24⅛	38⅜	16	9	2	20" × 25" × 2"	R260-3242
4-5968-1 filter assembly for -6000-H and -9000-L	40⅞	10⅛	25½	2 11/16	14⅝	—	3	20" × 25" × 2"	R260-3242

WARNING: Situations dangerous to personnel and property can develop from incorrect operation of combustion equipment. North American urges compliance with National Safety Standards and Insurance Underwriters recommendations, and care in operation.

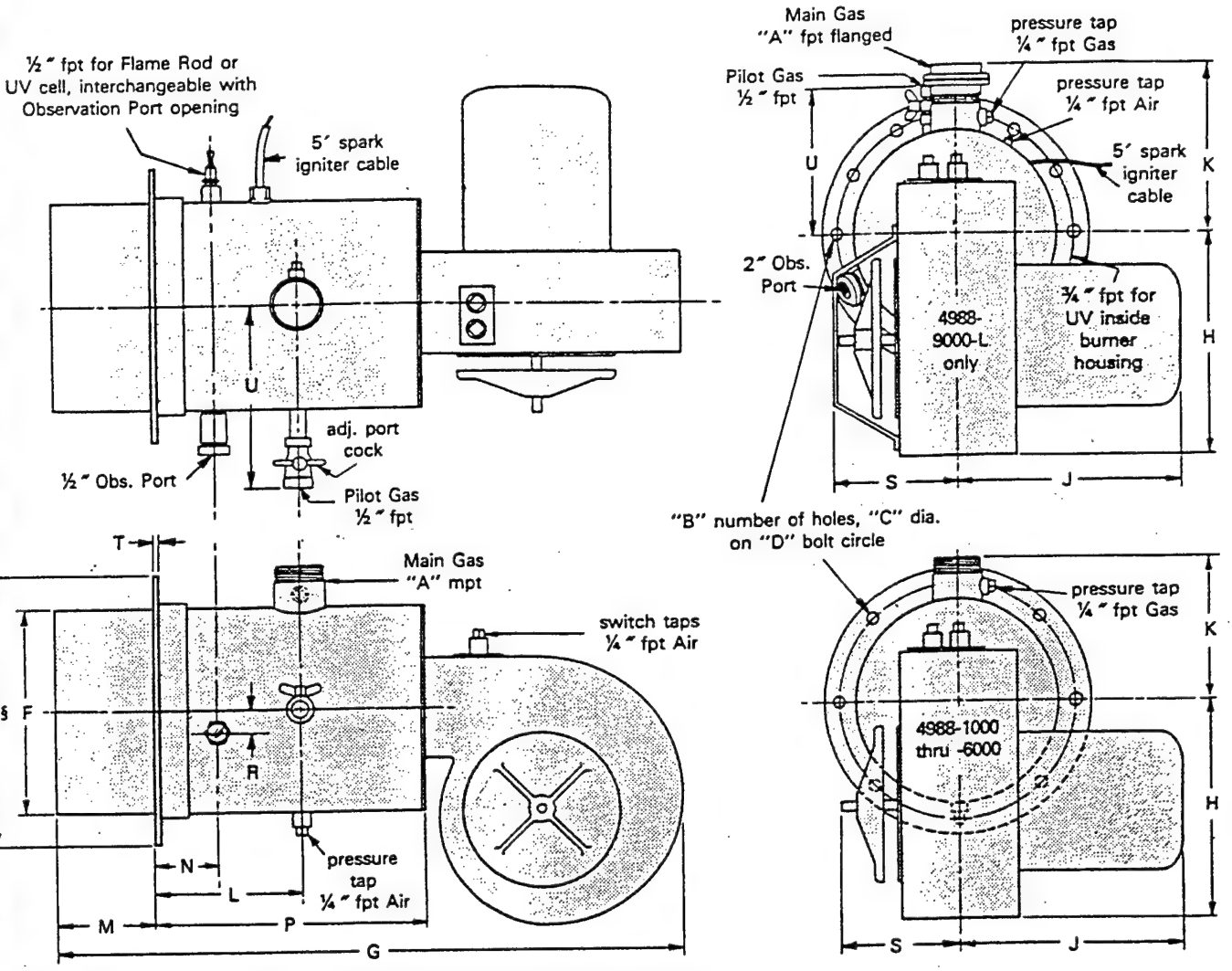
DIMENSIONS SHOWN ARE SUBJECT TO CHANGE. PLEASE OBTAIN CERTIFIED PRINTS FROM NORTH AMERICAN MFG. CO. IF SPACE LIMITATIONS OR OTHER CONSIDERATIONS MAKE EXACT DIMENSION(S) CRITICAL.

Adapter plates simplify mounting circular Zephyr flanges to square duct cutouts. All plates are 3/16" thick steel.

adapter plate for 4988-	dimensions in inches A	B	C	D	E	F	G	H	part no.
1000	14	7	½	4 5/16	—	12	5/16	8⅞	4-5506-1
2500	19	9½	½	6	—	12	5/16	12 15/16	4-5506-2
4000 & 6000	23	11½	½	7 5/16	—	12	5/16	17	4-5506-3
9000	31	15½	¾	7⅜	7⅜	16	9/16	23	4-6012-1



To order:
Specify part number of adapter plate.



DIMENSIONS SHOWN ARE SUBJECT TO CHANGE. PLEASE OBTAIN CERTIFIED PRINTS FROM NORTH AMERICAN MFG. CO. IF SPACE LIMITATIONS OR OTHER CONSIDERATIONS MAKE EXACT DIMENSION(S) CRITICAL.

dimensions in inches

Zephyr designation	A	B	C	D	E§	F	G_L†	G_H‡	H_L†	H_H‡	J_L†	J_H‡	K	L	M	N
4988-1000	1¼	8	11/32	9½	10⅝	8 1/16	24 3/16	25 13/16	7½	8⅞	9 13/16	9⅞	6½	5⅝	5	2¼
4988-2500	2	12	13/32	13 13/16	15 3/16	12⅛	32⅜	36 5/16	8 13/16	12⅛	11 9/16	12⅜	8⅝	10 3/16	6½	4⅛
4988-4000	3	16	13/32	18⅛	19¾	16⅛	42¼	42¼	12⅛	12⅛	12 13/16	14 9/16	10⅞	11¼	10	4¼
4988-6000	3	16	13/32	18⅛	19¾	16⅛	42¼	49⅞	12⅛	17⅛	13 9/16	16⅛	10⅞	11¼	10	4¼
4988-9000	4	12	⅝	25½	27⅜	22¼	54¾	—	17⅛	—	16⅛	—	17⅛	15½	10 5/16	—

Zephyr designation	P	R	S_L†	S_H‡	T	U	Observation Port	weight, lb 4988- -L	4988- -H	4988- -R	4988- -R SW style connection pipe size (inches)
4988-1000	10¾	¾	5 13/16	5 9/16	⅛	7½	8790-0	45	52	24	4 A round
4988-2500	15 13/16	1⅛	6 1/16	7 5/16	3/16	10¼	8790-0	88	117	57	6 SW connection,
4988-4000	18⅛	1¼	8 9/16	7 9/16	3/16	12⅝	8790-0	137	181	96	8 suitable for
4988-6000	18⅛	1¼	8 9/16	9¼	3/16	12⅝	8790-0	142	221	96	10 flexible sleeve or
4988-9000	22 11/16	—	9¼	—	⅜	13⅜	8790-4-A	300	—	180	12 welded connection

§ Allow at least 6" on each side to withdraw flame supervisory device or spark igniter.
† 4988- -L only.
‡ 4988- -H only.

To order, specify: 4988-(capacity designation)-any modifiers (L = low pressure fan, H = high pressure fan, R = remote blower, P or B = no charge modification for propane or butane--not required on -9000) electrical characteristics for burner blower motor.

Examples: 4988-1000-L Low Pressure Burner complete 115/1/60

4988-6000-HP High Pressure Burner complete for Propane 230-460/3/60

North American Manufacturing Company
4455 EAST 71ST STREET • CLEVELAND, OH 44105-5600 USA
PHONE (216) 271-6000 • FAX (216) 641-7852

PROPOSAL

INQUIRY NUMBER INCINERATION

SUBMITTED TO:
ARSONS COMPANY
700 BROADWAY STE 900
DENVER, CO 80290

QUOTE NUMBER	Z92266-115493
QUOTE DATE	07/20/98
TERMS	SPECIAL
F.O.B.	CLEVELAND, OHIO
DELIVERY	12-14 WEEKS
SIC	C200

ATTN: ED BONDAREWICZ
COPIES: PHONE: 303/764-8731
FAX: 303/831-8208

(PLEASE MAIL ORDER TO:)
NORTH AMERICAN MFG COMPANY
SUITE 101
1820 WEST ORANGEWOOD AVE
ORANGE, CA 92868
(714) 634-4891
FAX: 7146344595

SUBJECT: HOT GAS TECHNOLOGY INCINERATION

ITEM	QTY	PART NUMBER	DESCRIPTION	UNIT PRICE	EXTENSION
1			+APPLICATION: HOT GAS TECH INCINERATOR		
			SIZE: N/A		
			REFRACTORY: N/A		
			HEAT INPUT: 2 BURNERS @ 1.0MM BTU/HR EA		
			FUEL: 400 SCFH PROPANE/FUEL TRAIN		
			FUEL PRESSURE: 5-50 PSIG @ FUEL TRAIN INLET		
2			+ELECTRICAL: 460/3/60 POWER		
			120/1/60 CONTROL		
			INSTALLATION: OUTDOORS NEMA 3R MINIMUM		
			ELEVATION: SEA LEVEL		
			EMISSIONS: N/A		
3		TERMS	TERMS FOR THIS QUOTATION ARE TO BE DETERMINED.		
10	2	4988-1000-HP	HI PRESS BURNER F/PROPANE 460/3/60		
20	2	4-5676-1	FILTER ASSEMBLY F/4988-1000		
30	2	8757-A902	PRESSURE SWITCH		
40	2	8777-2	1-1/4" FLEXIBLE NIPPLE		
50	2	8522-XX	ENGINEERED FUEL TRAIN		
60		1)1821-0	3/4" BALL VALVE		
70		1)8558A-0-40	3/4" 40 MESH Y-TYPE STRAINER		

North American Manufacturing Company
4455 EAST 71ST STREET • CLEVELAND, OH 44105-5600 USA
PHONE (216) 271-6000 • FAX (216) 641-7852

PROPOSAL

INQUIRY NUMBER INCINERATION

QUOTE NUMBER Z92266-115493
QUOTE DATE 07/20/98

SUBMITTED TO:
ARSONS COMPANY
1700 BROADWAY STE 900
DENVER, CO 80290

ITEM	QTY	PART NUMBER	DESCRIPTION	UNIT PRICE	EXTENSION
80		1) 8735-M	0-60 PSI GAUGE		
90		1) 1836-03	1/4" NEEDLE VALVE		
100		1) 7347-0-A	3/4" REGULATOR		
110		1) 8735-HM	0-32 OSI GAUGE		
120		1) 1836-03	1/4" NEEDLE VALVE		
130		1) 8757-C437F1045	PRESSURE SWITCH RG 1-26" WC		
140		1) 1595-0-PV	3/4" DOUBLE SHUT-OFF VALVES		
150		1) 8757-C437F1052	PRESSURE SW RG .5-5 PSIG		
160		1) 1821-0	3/4" BALL VALVE		
170		1) 8697-0-A468	3/4" ORIFICE METERING SYSTEM		
180		1) 1008-0	3/4" ADJ PORT VALVE B&L FOR DR410-2380		
190		1) R410-2380	CONTROL MOTOR		
200		1) 1821-01	1/2" BALL VALVE		
210		1) 7345A-01	1/2" REGULATOR		
220		1) 1486A-01	1/2" SOL GAS SHUTOFF VALVE		
230		1) 4065-6N4-6A	NEMA 4 TRANS 120 TO 6000V		
240	1	8865	FLAME SUPERVISORY SYSTEM AND CONTROL PANEL including:		
250		2) R860-4375	UDC 3300 CONTROLLER WITH REMOTE SETPOINT		
260		2) R860-4352	DC300L HIGH TEMP CONTROLLER		
270		2) R130-5368	PROTECTORELAY RM788A1027		
280		2) R130-5376	REMOTE RESET MODULE		
290		2) +	HONEYWELL KEYPAD DISPLAY MOUNTED IN DOOR		
300		1) R315-2045	ALARM HORN NEMA 4		
310		2) +	1/2HP MOTOR STARTERS		
320		1) +	NEMA 4 ENCLOSURE		
330		1) +	FLANGE MOUNTED DISCONNECT		
340		2) +	LOCAL/REMOTE START/STOP FOR TWO BURNERS.		
350		1) +	NEMA 4X SST WINDOW HINGED W/LATCH, DOOR MOUNTED		
360		3) +	MANUALS WITH DRAWINGS		
370		1) +	UL LISTED		
380		+	FOR FIELD SERVICE ASSISTANCE REFER TO N.A. M9-E OR M9 PRICE SHEETS.		

North American Manufacturing Company
4455 EAST 71ST STREET • CLEVELAND, OH 44105-5600 USA
PHONE (216) 271-6000 • FAX (216) 641-7852

PROPOSAL

INQUIRY NUMBER INCINERATION

QUOTE NUMBER Z92266-115493
QUOTE DATE 07/20/98

SUBMITTED TO:
PARSONS COMPANY
1700 BROADWAY STE 900
DENVER, CO 80290

ITEM	QTY	PART NUMBER	DESCRIPTION	UNIT PRICE	EXTENSION
90		+	PRICE DOES NOT INCLUDE, BUT MAY BE QUOTED LATER IF THE CUSTOMER WISHES: - FIELD MOUNTED EQUIPMENT. - SPECIAL CUSTOMER SPECIFICATIONS. - CONTROLLERS UNLESS NOTED.		
00		+	- CUSTOMER APPROVAL OF ALL ELECTRICAL DRAWINGS. - CUSTOMER WITNESSING OF THE CONTROL PANEL TEST AT NAMCO.		
10	2	4085-20	20FT OF IGNITION CABLE		
20	2	R130-5841	C7027A1049 UV DETECTOR		
30	1	LS	LUMP SUM TOTAL	49850.00	49850.00
			QUOTE TOTAL		49850.00

rices firm for 30 days for orders placed for delivery anytime within 4 months rom date of order based on quoted delivery time. For quoted delivery time see the front page of this quotation. If design, manufacturing or shipment is elayed more than 4 months at customers request, prices will be those in ffect at the time of shipment.

THIS PROPOSAL PREPARED BY:

GREG HOWLAND COMBUSTION AND CONTROLS ENGINEER
NORTH AMERICAN MFG CO ORANGE, CALIFORNIA

the interest of safety, North American joins NFPA and insurance underwriters in urging the use of electronic flame supervision on most fuel-burning applications. The decision whether or not to incorporate flame supervision rests with e owner and his insurance underwriter. If desired, North American can provide information concerning safety standards they apply to your application.

U.S. Distributing, Inc.

2333 Cole Street ◆ Birmingham, Michigan 48009
(248)646-0550 ◆ FAX (248)646-8942

April 14, 1998

Mr. Ed Bondarewicz
Parsons Engineering Science, Inc.
1700 Broadway Suite 900
Denver, CO 80290

Dear Ed:

U.S. Distributing, Inc. has been the leader in the temporary heating industry since 1972. With 26 years of experience, you can be assured that we understand the tremendous responsibility that comes with the construction of today's building. That is why, with careful planning, we can help prevent time delays and cost overruns on your project.

With our full line of SunDog temporary gas fired heaters, all certified by the A.G.A. (American Gas Association) to assure maximum safety in the field, our engineers are able to design a temporary heating system around your requirements. After a careful inspection of your project, we can provide an accurate proposal recommending the type and quantity of heaters, placement of units, electrical requirements, fuel estimate and pricing.

All SunDog heaters are available for rent by the week, month or heating season. Additionally, we offer a very attractive purchase program for those interested in owning their own heaters. All systems are delivered, set-up, and backed by our well trained service staff that is on call 24 hours a day, seven days a week.

We are offering this service to all of your personnel that may need temporary heat in this upcoming Winter season. It's never too early to start planning for your Winter protection. If you give us the opportunity, I know you will be very happy you chose SunDog Construction Heaters. The only full service temporary heating supplier!

I have enclosed a brochure of our complete product line for your review. If you should need any additional information or assistance, please feel free to call.

Best regards,

Robert S. Reid

U.S. Distributing, Inc.

2333 Cole Street ◆ Birmingham, Michigan 48009
(248)646-0550 ◆ FAX (248)646-8942

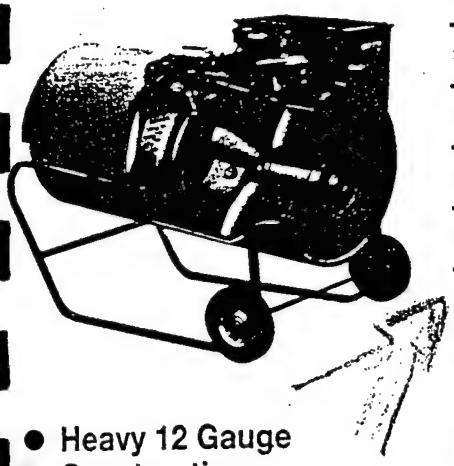
SUNDOG HEATERS 10/29/96

MODEL NO.	DESCRIPTION	TRADE PRICE	DAY	WEEK	MONTH
SDT-2500	2,000,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	10,500.00	250.00	600.00	1,200.00
SUN-2500	2,500,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	13,500.00	250.00	600.00	1,200.00
SUN-1400	1,400,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	7,700.00	225.00	550.00	1,050.00
SUN-1000	1,000,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	6,300.00	200.00	375.00	850.00
SROT-1500	1,000,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	5,900.00	175.00	350.00	775.00
SUN-700	700,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	5,800.00	165.00	340.00	750.00
SUN-400	400,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	4,900.00	100.00	250.00	550.00
SUN-250	250,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	3,100.00	90.00	175.00	400.00
SUN-150	150,000 BTU CAPACITY FOR OPERATION ON LOW PRESSURE NATURAL GAS OR PROPANE	2,500.00	75.00	150.00	350.00

$150.00 DELIVERY CHARGE PER UNIT **THREE DAY MINIMUM ON DAILY RENTAL**

MOVINCOOL®
SPOT COOLING SYSTEMS

Gas Fired Heaters



- Heavy 12 Gauge Construction
- Stainless Steel Burner Assembly - Complete Combustion
- Dual Solenoid Valves
- Electronic Flame Safeguard
- Ultra Violet Scanner
- Cast aluminum Prop
- 120 Volt
- Totally Enclosed Fan Cooled Motor
- Easy Portability

SPECIFICATIONS

Model	Output	Fuel	Manifold Pressure	Gas Consumption	Fan	Performance	Thermostat	Gas Connections	Dimensions	Weight
SUN150	150,000	PROPANE	1.0" W.C. LPG	1.64 GAL/HR. LPG	LAU 12" 4 BLADE PROPELLER-ROTATION C.C.W.	650 CFM 260 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	1/2" N.P.T.	LENGTH 31" WIDTH 22" HEIGHT 23"	100 LBS
	150,000	NATURAL GAS	2.0" W.C.	150 CFH						
SUN250	250,000	PROPANE	1.0" W.C. LPG	2.73 GAL/HR. LPG	LAU 16" 4 BLADE PROPELLER-ROTATION C.C.W.	1200 CFM 260 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	1/2" N.P.T.	LENGTH 40" WIDTH 27" HEIGHT 29"	150 LBS
	235,000	NATURAL GAS	2.55" W.C.	235 CFH						
SUN400	400,000	PROPANE	1.0" W.C. LPG	4.37 GAL/HR. LPG	HARTZELL 18" 4 BLADE PROPELLER-ROTATION C.C.W.	1200 CFM 300 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	3/4" N.P.T.	LENGTH 45" WIDTH 28" HEIGHT 35"	220 LBS
	665,000	NATURAL GAS	2.3" W.C.	665 CFH						
SUN700	700,000	PROPANE	1.3" W.C. LPG	7.65 GAL/HR. LPG	HARTZELL 20-1/2" 4 BLADE PROPELLER-ROTATION C.C.W.	1800 CFM 300 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	1" N.P.T.	LENGTH 51" WIDTH 32" HEIGHT 41"	280 LBS
	700,000	NATURAL GAS	4.0" W.C.	700 CFH						
SUN1000	1,000,000	PROPANE	2.0" W.C. LPG	10.9 GAL/HR. LPG	HARTZELL 20-1/2" 4 BLADE PROPELLER-ROTATION C.C.W.	2000 CFM 300 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	1" N.P.T.	LENGTH 51" WIDTH 32" HEIGHT 41"	280 LBS
	1,000,000	NATURAL GAS	4.4" W.C.	1000 CFH						
SUN1400	1,400,000	PROPANE	2.5" W.C. LPG	115.3 GAL/HR. LPG	HARTZELL 22-1/2" 6 BLADE PROPELLER-ROTATION C.C.W.	3400 CFM 460 DEGREE TEMP. RISE	CONTROL RANGE 35-110 DEGREES FAHRENHEIT	1-1/4" N.P.T.	LENGTH 54" WIDTH 32" HEIGHT 41"	330 LBS
	1,200,000	NATURAL GAS	3.5" W.C.	1200 CFH						
SUN2000	2,000,000	PROPANE	1.5" W.C. LPG	21.86 GAL/HR. LPG	S.W.S.I 20" CENTRIFUGAL FAN	6000 CFM 300 DEGREE TEMP. RISE	CONTROL RANGE N/A	2" N.P.T.	LENGTH 110" WIDTH 33" HEIGHT 54"	1000 LBS
	2,000,000	NATURAL GAS	5.0" W.C. NG	2000 CFH						

CONTROLS

Electrical Functions	SUN150	SUN250	SUN400	SUN700	SUN1000	SUN1400	SUN2000
Air Safety Switch	✓	✓	✓	✓	✓	✓	✓
High Limit Switch	✓	✓	✓	✓	✓	✓	✓
Thermostat	✓	✓	✓	✓	✓	✓	✓
RAM I Flame Control	✓	✓			✓		
Honeywell Flame Control				✓			
Fireye Control			✓			✓	✓
Flame Rod Sensor	✓	✓		✓	✓		
Ultra Violet Scanner			✓			✓	✓

APPLICATIONS

This heater is suitable for all heating applications, including high rise construction particularly hotels and office complexes, concrete curing, wet trade finishing, painting, frost removal, fire proofing, and creature comfort. These heaters offer a considerable fuel savings because of the efficiency of the design as well as being thermostatically controlled. They are designed and built by U.S. Distributing to meet rigid ANS Z83.7b - 1989 standards and are certified by AGA to that design. All service and maintenance are performed by qualified factory trained personnel. We maintain our own service vehicles, completely equipped with SUNDOG replacement parts for on-site service on a 24-hour basis, seven days a week.

SECTION 2

THERMAL FABRIC, INSULATION AND FLEXIBLE CONNECTORS

BGF Industries, Inc.

May 14, 1998

Mr. Ed Bondarewicz
Parsons Engineering Sciences Inc.
1700 Broadway, Suite 900
Denver, CO 80290

Dear Mr. Bondarewicz:

Thank you for visiting BGF's website and your interest in our fiberglass fabrics. After conversations with our R & D area we feel that a non-woven insulation may be the best choice for your application. Enclosed are samples of our 1/2" and 1" BGF Mat along with a product brochure. The 3EPlus2.1 software is what we use to determine the thickness needed depending on the temperature variables.

I have also enclosed a sample of Style 7721 with our flame resistant finish, 972B. This style is used as a smoke curtain, to contain any outbreak of a fire in buildings. If this looks to be of interest I can provide you with a larger sample if necessary.

Please contact me if I can be of further assistance.

Best regards.

Elisabeth Cox

Elisabeth Cox
Cox-ParsonsEngr
Scien.5-14-98L-js

Enclosures

cc: Mary Causey
Bill Schwartz

BGF Mat®

t ffers excellent sound absorption properties and e' stance to vibration without powdering.

B F Mat meets U.L. #R11184 and is listed 0-flame sp ad and 0-smoke generation. It conforms with military specifications MIL-I-24244 and MIL-I-16411, al ertinent automotive specifications, and is recorded as STM-C-1086-88.

B F Mat is available in standard 1/4", 1/2", 3/4" an 1" grades.

APPLICATIONS

- emovable pads
- iip turbines
- Marine, industrial, and process piping
- uffler insulation
- ower generating equipment
- Industrial furnaces and ovens
- utomotive floor and front dash insulation
- ltration
- Supercharger covers
- Many other specialty applications requiring uality insulation

COUSTICAL RATINGS

F. quency (Hz)	1/4"	1/2"	1"
250	.04 ± .04	.07 ± .02	.29 ± .04
500	.17 ± .02	.30 ± .03	.86 ± .03
1000	.40 ± .04	.72 ± .08	.95 ± .04
2000	.68 ± .03	.94 ± .05	.92 ± .03
4000	.94 ± .05	.97 ± .05	.95 ± .05
Noise Reduction Co-efficient (NRC)	.30	.50	.75

HYSICAL PROPERTIES

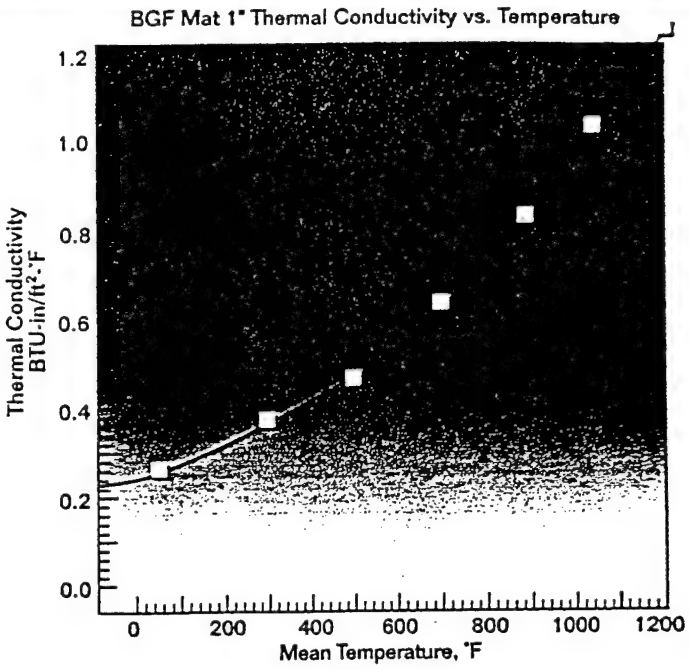
ade*	Mass (oz./sq. ft.)	Width* (inches)	Roll Length* (feet)	Area (sq. ft.) (per roll)	Roll Mass (net) (lbs.)
1/4"	3	60	150	750	185
1/2"	6	60	75	375	140
3/4"	12.25	60	45	225	172
1"	15	60	45	225	215

above information represents nominal values. *Grade, width and roll length can be made to order.

ERMAL CONDUCTIVITY

According to independent testing, BGF Mat® meets and exceeds the llowing "K" factor requirements for MIL-I-16411,Type II:

Temperature	BTU-in/ft²-hr-°F
300°F	.40
500°F	.50
700°F	.65



HULLBOARD STYLE 3732 AND HULLBOARD TAPE 28T

Navy board facing material (Style 3732 with 261 finish, patent #4,778,544 Low Toxic Navy Board Facing, meets MIL-C-20079, Type I, Class 2) is used extensively in the interior of ships to cover bulkheads and passageways.

BGF glass fabric is woven with 100% fiberglass to ensure flame retardancy, insulating protection, and durability. The hullboard fabric, when perforated, allows the thick backing material to absorb noise.

BGF's 261 finish has low chlorides, low toxicity, and a Class A rating with respect to Flame Spread and Smoke Developed when tested in accordance with NFPA 255 "Method of Test of Surface Burning Characteristics of Building Materials" (ASTM E-84). Its benefits include:

- Rigidity to span non-uniformities in the board carrier and ease in fabrication.
- Slitability to aid in fabrication, sizing, and handling of boards.
- Protection, easy cleaning, and strength.
- Accepts both oil-based and latex paints.

BREAKING STRENGTH

3732-261 finish meets the following properties specified under MIL-C-20079, Type 1, Class 2:

	Lbs./in. width
Warp Breaking Strength	300 Min
Fill Breaking Strength	255 Min
Heat-Aged Warp Breaking Strength	70 Min
Heat-Aged Fill Breaking Strength	60 Min

CONSTRUCTION INFORMATION

	Construction ends/inch	Weight oz./sq.yd.	Thickness inches
732/49.5"	W: 48 ± 2	13.5 ± 2.0	.165 ± .025
Also available in slit widths	F: 32 ± 2		
BT	W: 42 ± 2	5.8 ± 0.58	.0070 ± .001
Available in 2", 3", 4" and 6"	F: 32 ± 2		

PAD AND LAGGING FABRICS

BGF's pad and lagging fabrics are manufactured of 100% fiberglass yarns, so they're 100% asbestos-free. They are resistant to high temperatures and are easy to handle, cut, and sew. We use texturized yarns for maximum coverage and ease in processing. Combined with our wide range of finishes, the fabrics offer superior resistance to heat and water and satisfy our customers' specific performance requirements. Our pad and lagging fabrics are certifiable to MIL-C-20079, MIL-I-24244 and U.S. Navy requirements, including a requisite red finish color.

APPLICATIONS

- Expansion joints
- Pipe lagging
- Removable flange & valve covers
- Safety clothing
- Heat shields
- Spray shields
- Insulation pads

FINISHES

- **603A**: Multipurpose pad covering and lagging finish, providing good hand, minimal dust, and ease of fabrication.
- **604A**: Similar to 603A with the addition of a degree of oil and water repellency (not applicable to MIL-C-20079).
- **610A**: A pre-applied, rewettable lagging finish that is water activated and provides ease of application. After fabric has dried, normal sizing or painting is required.
- **208**: Comparable to 603A but pigmented red to indicate non-asbestos material. Meets MIL-C-20079.

PAD & LAGGING FABRIC

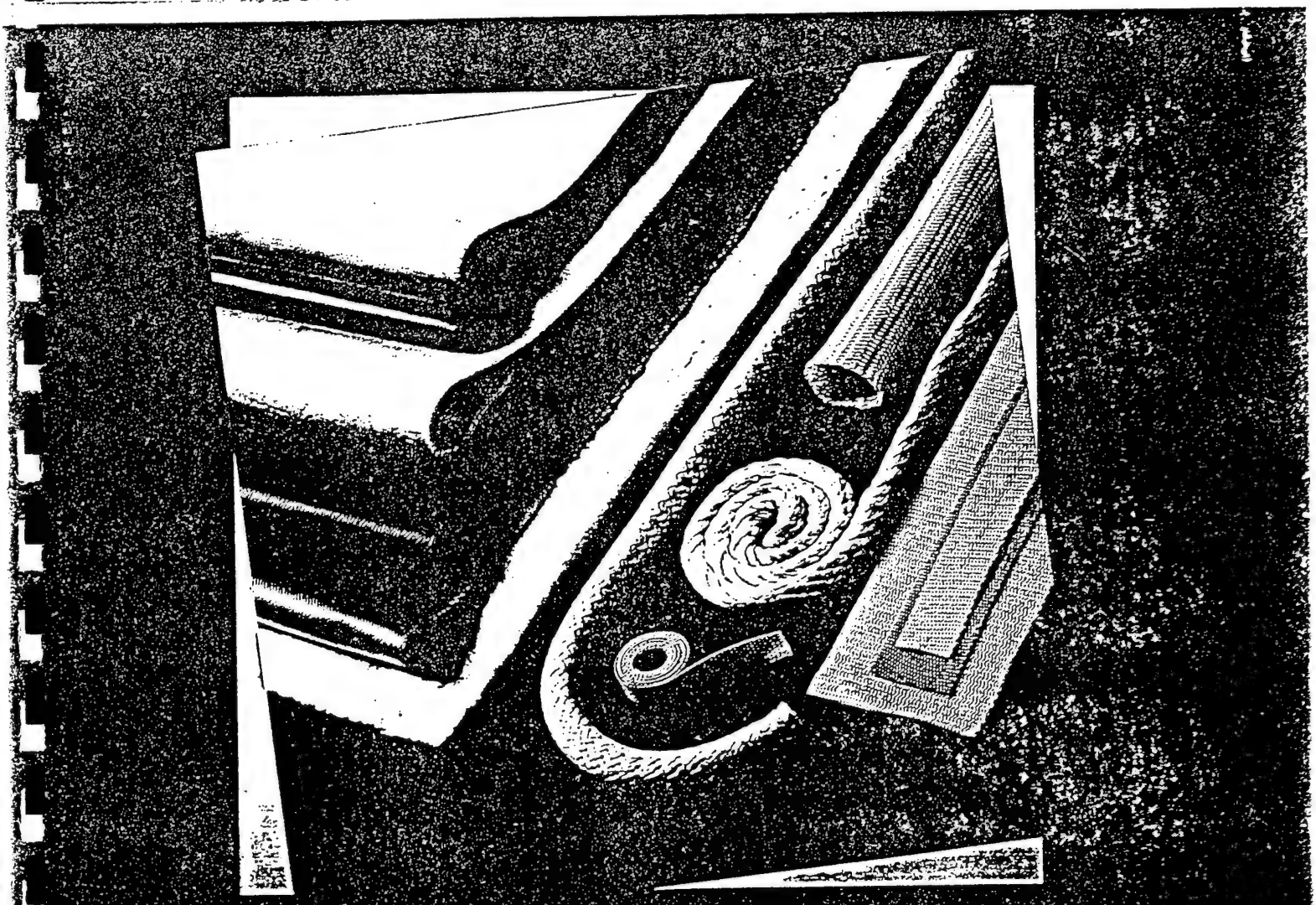
	PAD	LAGGING			
STYLES:	1926	1952	1959 2-End	1979 2-End	1989 2-End
WEAVE:	Plain	Plain	Plain	Plain	Plain
Construction:					
Warp ends/inch	20 ± 2	18 ± 2	20 ± 2	18 ± 2	18 ± 2
Filling picks/inch	14 ± 2	14 ± 2	16 ± 2	14 ± 2	14 ± 2
Weight (oz./sq.yd.)					
Untreated	17.7 ± 10%	8.5 ± 10%	12.8 ± 10%	8.5 ± 10%	8.5 ± 10%
603A	17.7 ± 10%	8.5 ± 10%	12.8 ± 10%	8.5 ± 10%	8.5 ± 10%
604A(Oil Resistant)	17.7 ± 10%	8.5 ± 10%	12.8 ± 10%	8.5 ± 10%	
610A	–	14.5*	22.0*	14.5*	14.2*
208 (Red)	17.7 ± 10%	8.5 ± 10%	12.8 ± 10%	8.5 ± 10%	
*Minimum Weight					
Breaking Strengths (Breaking strengths vary with finish)					
Warp	200	100	125	100	80
Fill	100	45	80	40	40

MILITARY SPECIFICATIONS

These are class numbers met under MIL-C-20079, Type1. Classes 3-9 automatically qualify under requirements for incombustibility as specified by USCG 49CFR164.009 before and after treatment. Also, Classes 1-10 meet special corrosion, chloride and fluoride requirements of MIL-I-24244.

	1926	1952	1959	1979
Untreated	–	4	8	6
603A	9	3	7	5
604A(Oil Resistant)	9	3	7	5
610A	–	4	8	6
208(Red)	9	3	7	5

HIGH TEMPERATURE TEXTILES



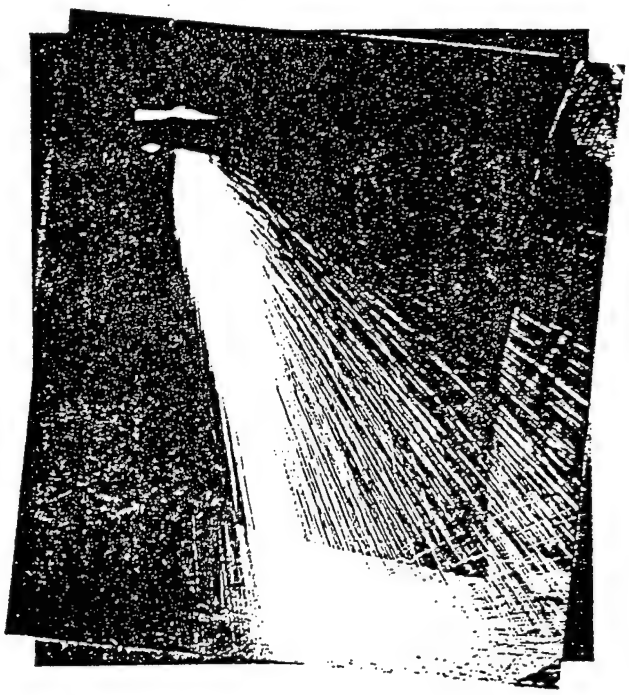
Silica textiles for Welding, Insulation, Shipbuilding, Power Generation, Metal Processing, Aerospace, and other industries.

SILTEMP® HAVEGLAS™ ULTRA-SIL®

HIGH-TEMPERATURE TEXTILES

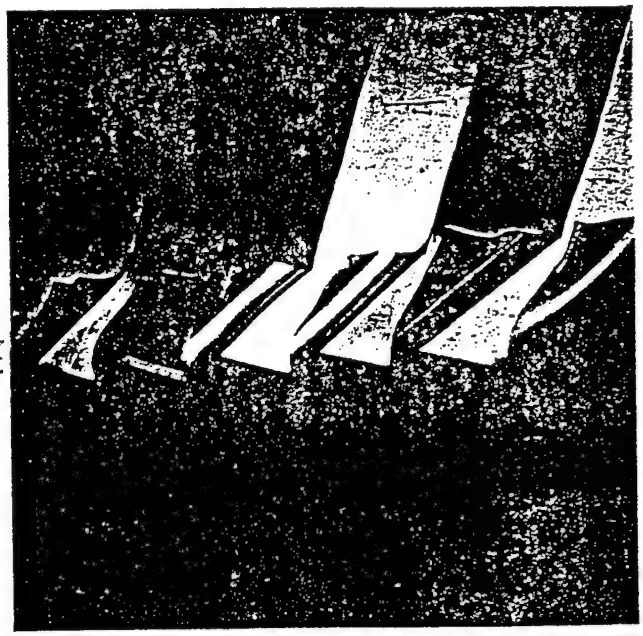
AMETEK high temperature fabrics are designed for use as an environmentally approved replacement for asbestos in a wide range of insulation and protection applications. Ametek textile products provide high thermal resistance for applications in aerospace, marine, molten metal, and power industries.

SILTEMP® Silica Fabrics



When critical applications require safeguarding personnel and equipment against extreme temperatures, sparks, and molten metals—*Siltemp takes the heat.* **Siltemp silica textile fabrics can be used or configured as: welding drop cloths, protective screens, fire curtains, stress relief blankets, furnace insulation, cable wrap, and high temperature gaskets.** Siltemp is available in fabric, tape, rope, sleeving, mat, and yarn forms. Siltemp fabrics can be specified with aluminized, silicone, and other coatings for special application requirements. All Siltemp fabrics, excluding pre-shrunk, are hydrocarbon-coated to improve handling characteristics. The coating is designed to decompose at high temperatures, and generates virtually no smoke or fumes. Siltemp has a minimum silicon dioxide (SiO_2) content of 96%, and resists most corrosive fluids.

Standard Grade Siltemp fabrics—the most frequently specified products in our line—are suitable for most "hot" applications. *Abrasion Resistant Siltemp* is designed for durability and low temperature abrasion resistance. *Water-repellent Siltemp* should be used in applications involving water or oil. *Pre-shrunk Siltemp* fabrics can be supplied in *Commercial Grade* for applications requiring minimum shrinkage at high temperatures, and in *Aerospace Grade* for highly technical aerospace composite moldings. *Silicone Coated Siltemp* is designed for uses where surface abrasion and impermeability to fluids and gases are important. *Aluminized Siltemp* provides thermal reflectivity and is ideal for fabrication of covers.



Product Type	Product Number	Color	Nominal Thickness, Inches	Nominal Weight Oz./Yd.²	Nominal Width, Inches
Standard	84CH	Tan	0.030	18	36
	188CH	Tan	0.054	36	36
Abrasion Resistant	84CSR	Tan	0.030	18	36
	188CSR	Tan	0.054	36	36
Water Repellent	WR84CSR	Tan	0.030	18	36
	WR188CSR	Tan	0.054	36	36
Pre-Shrunk	82S	White	0.015	10.3	33
	84S	White	0.026	18.5	33
	188S	White	0.052	38.0	33
Aluminized*	ALUM 84CH	Silver	0.033	21	34-1/2
	ALUM 188CH	Silver	0.057	39	34-1/2
Silicone*	SIL RUB84CH	Red	0.033	24	36
	SIL RUB 188CH	Red	0.057	42	36

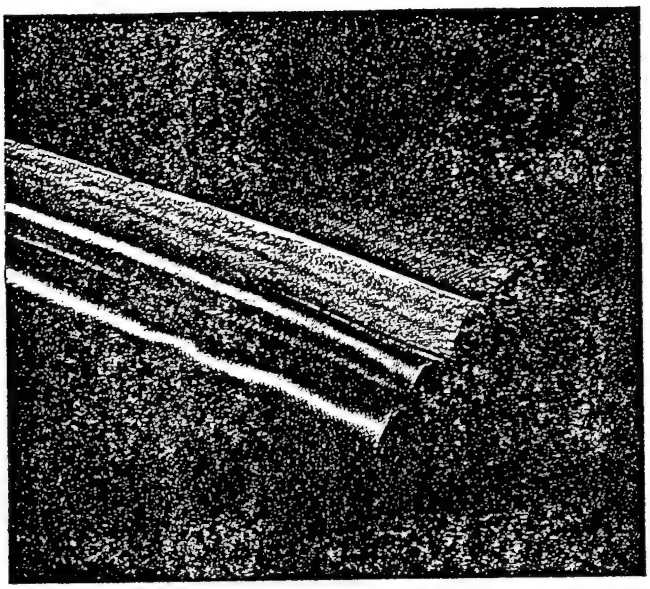
Standard roll length is 50 yards; shorter or longer rolls are available on request.
**Coated 1 side; 2 side coating is available on request. Coatings will lose properties as temperature increases. Silicone coating is also available in other colors.*

ULTISIL® Silica Fabrics

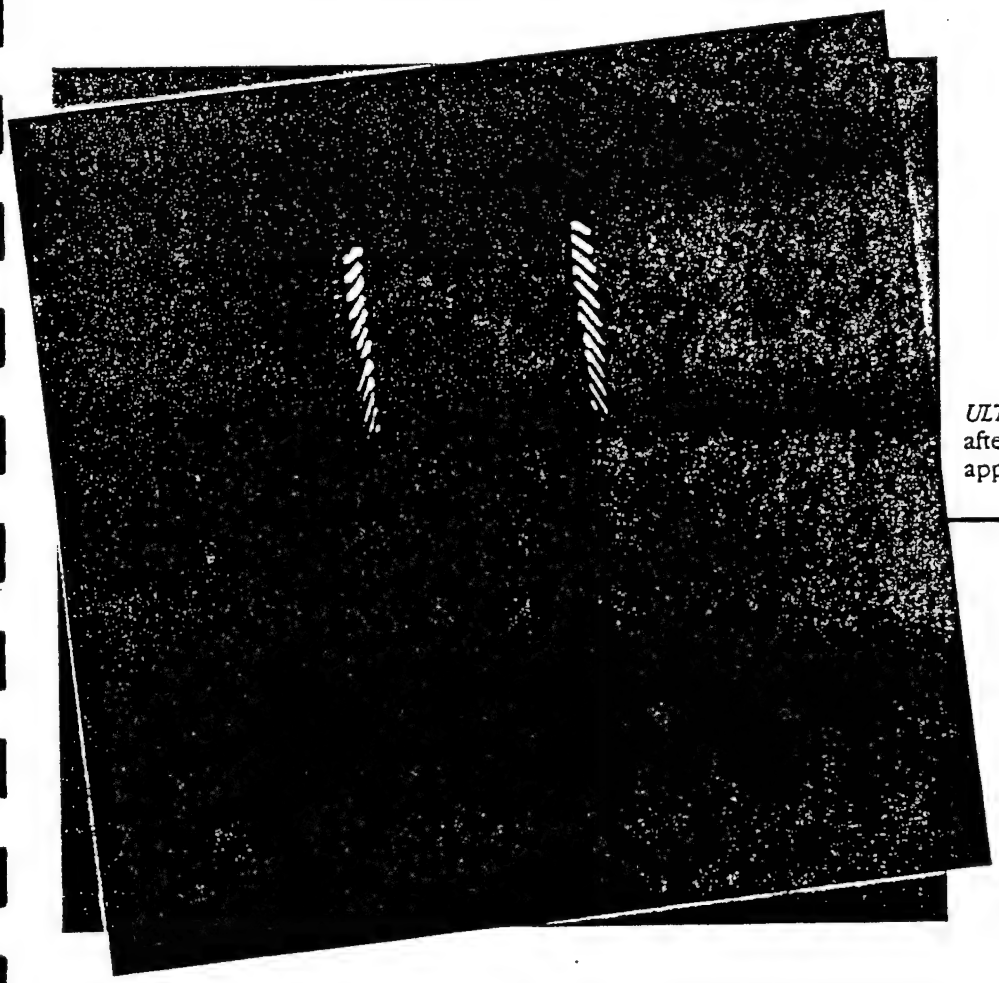
ULTISIL High Temperature Textiles are specially treated silica fabrics that provide higher temperature capability than standard silica cloth. *ULTISIL* fabrics incorporate all of the outstanding qualities of our *SILTEMP* products, with the added performance benefits of increased strength and flexibility at temperatures ranging up to 2300°F (1260°C).

ULTISIL fabrics are ideal for furnace curtains, stress relief blankets, expansion joints, composites, seals, gaskets, insulations involving encapsulation of refractory wools, and a wide range of aerospace applications.

Product Type	Product Number	Color	Nominal Thickness, Inches	Nominal Weight, Oz./Yd.²	Nominal Width, Inches
Standard	HT84CH	Tan	0.030	18	36
	HT188CH	Tan	0.054	36	36
Pre-Shrunk	HT84S	Orange	0.030	18	33
	HT188S	Orange	0.054	36	33
Pre-Shrunk (Coated)	HT84SH	Orange	0.030	18	33
	HT188SH	Orange	0.054	36	33



"The Ultimate in Silica"



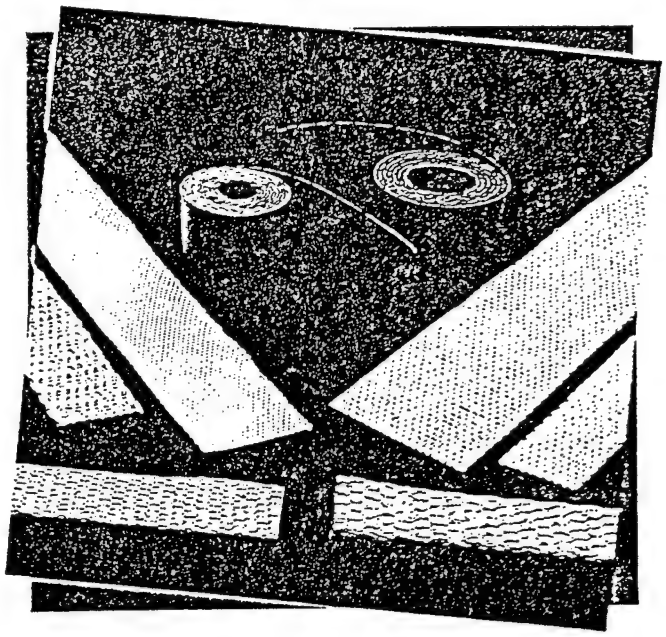
ULTISIL fabric maintains flexibility after exposure in furnace curtain applications up to 2300°F (1260°C)

SILTEMP® Silica Tapes

WOVEN TAPE

Siltemp Woven Tape has selvaged edges to prevent raveling. WT36CH and WT65CH have a coating that improves low temperature handling and decomposes at high temperatures. Woven Tape is used as insulation for wrapping hot pipes, and to protect hoses and cables from heat, fire and molten metals. Other applications include seals, gaskets and vertical strip furnace curtains.

Product Number	Width, Inches	Nominal Thickness, Inches	Nominal Roll Length, Feet
WT-19-1-1/2	1-1/2 ± 1/8	0.020	100
WT36CH-1	1 ± 1/8	0.050	100
WT36CH-1-1/2	1-1/2 + 0-1/8	0.050	100
WT36CH-2	2 + 0-1/8	0.050	100
WT36CH-4	4 + 0-1/4	0.050	100
WT36CH-6	6 + 0-1/2	0.050	100
WT65CH-1	1	0.090	50
WT65CH-1-1/2	1-1/2 + 0-1/8	0.090	50
WT65CH-2	2 + 0-1/8	0.090	50
WT65CH-4	4 + 0-1/4	0.090	50
WT65CH-6	6 + 0-1/2	0.090	50

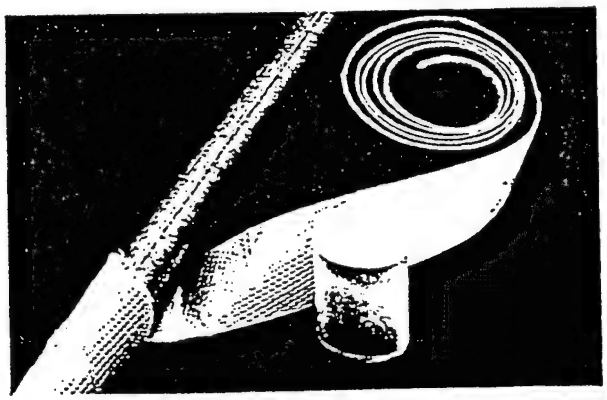


ADHESIVE BACKED TAPE

Siltemp Adhesive-backed Tape combines non-raveling properties of woven tape with an adhesive system to facilitate protective wrapping of pipes, hoses and cables. The adhesive system will decompose at high temperatures. Other adhesive-backed fabrics can be custom slit on request.

Product Number	Width Inches	Nominal Thickness, Inches	Nominal Roll Length, Feed
ST84CHAB-1	1	0.030	150
ST84CHAB-1-1/2	1-1/2	0.030	150
ST84CHAB-2	2	0.030	150
ST84CHAB-4	4	0.030	150
ST188CHAB-1	1	0.054	75
ST188CHAB-2	2	0.054	75
ST188CHAB-2	4	0.054	75

Other widths available upon request



SLIT TAPE

Siltemp Slit Tape is obtained by slitting full width fabric rolls. The slit tape has the same characteristics and high temperature properties as woven tape. Other fabrics including neoprene, silicone and aluminized coated fabrics can be custom slit on request. Slit tape is coated to improve low temperature handling properties and minimize raveling. The coating will decompose at high temperatures. Other widths are available on request.

Product Number	Width, Inches	Nominal Thickness, Inches	Nominal Roll Length, Feet
ST36CH-1	1	0.050	135
ST36CH-2	2	0.050	135
ST36CH-3	3	0.050	135
ST36CH-4	4	0.050	135
ST36CH-6	6	0.050	135

HIGH TEMPERATURE TEXTILES

SILTEMP® Insulation Products

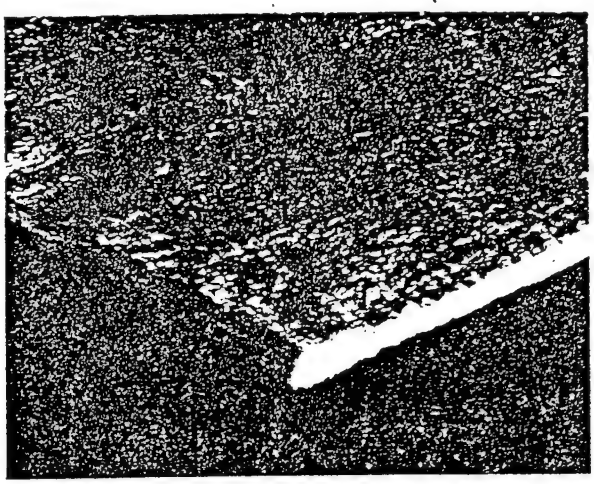
THERMAL BLANKET

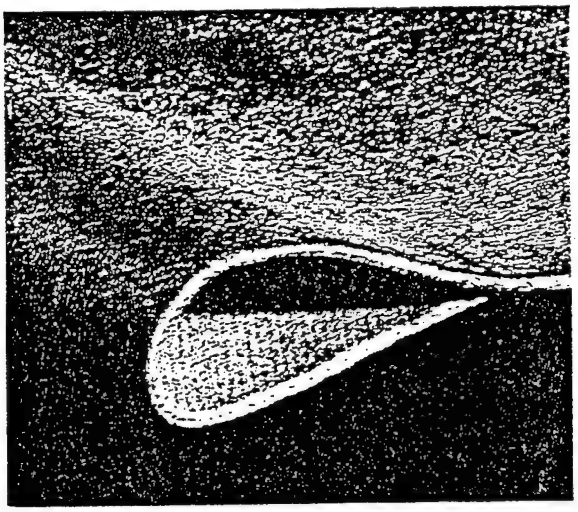
SILTEMP® Thermal Blanket is a high temperature insulation made from amorphous silica. *SILTEMP Thermal Blanket* is an ***excellent alternative to refractory ceramic fiber (RCF) insulation.***

SILTEMP Thermal Blanket has outstanding high temperature properties and is ideal for furnace insulation, for turbine covers, expansion joints, and for heat treating and piping applications.

Product Type	Nominal Thickness, Inches	Nominal Density Lb/Ft^3	Nominal Width, Inches
Thermal Blanket 1/2"	1/2"	10	36
Thermal Blanket 1"	1"	10	36

**Siltemp Thermal Blanket 1/2" comes in 60 ft. rolls; the 1" material comes in 40 ft. rolls.*





SEWING THREAD

Metalized Sewing Threads should be used for fabricating items where thread breakage may be a problem, and where high temperature resistance is required. *Silica Yarn* composed of amorphous silica continuous filament is designed for applications involving high temperature, electricity, or corrosive substances.

Metalized Product Number	Nominal Diameter, Inches	Thread, Number Plies	Nominal Spool Length, Meters
20	0.016	2	3000
13	0.020	3	3000

Silica Product Number	Nominal Diameter, Inches	Nominal Cone Weight, Oz.	Nominal Cone Length, Yards
Y-40	0.040	24	1050
Y-50	0.050	24	500

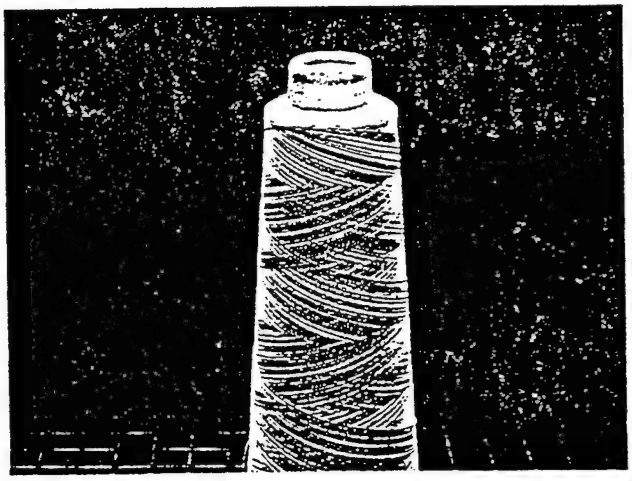
Yams may also be obtained with a polytetrafluoroethylene (PTFE) coating to improve handling properties.

SILTEMP® 25M Mat

SILTEMP 25M Mat is a pre-shrunk, high temperature insulation with excellent thermal properties. Low areal shrinkage, outstanding dimensional stability, and high strength characteristics of *SILTEMP 25M Mat* have made it a preferred choice as a base for resin impregnation for aerospace applications. Other typical *SILTEMP 25M Mat* applications include: furnace covers, stress relief blankets, and high temperature insulation.

Product Type	Nominal Thickness, Inches	Nominal Density Lb./Ft.^{3}	Nominal Width, Inches	Nominal Area Shrinkage
25M Mat	1/4"	13	31.5	<3.0%

**Siltemp 25M Mat comes in 90 ft. rolls*



DISTRIBUTED BY

For additional information on AMETEK High Temperature Textiles contact your local distributor or call:

302-995-0400

Ametek cannot predict all of the potential applications for which customers may attempt to use Siltemp products. SILTEMP PRODUCTS WILL HAVE VARYING DEGREES OF EFFECTIVENESS FOR EACH POTENTIAL APPLICATION DEPENDING ON THE MAXIMUM TEMPERATURE ATTAINED, THE LENGTH OF USE, AND THE AMOUNT OF TEMPERATURE FLUCTUATION. If the customer has any questions regarding the use of Siltemp products in a particular application, please contact Ametek Chemical Products Division at (302) 995-0400 and we will provide a sample of Siltemp for testing. This product is not warranted against injuries or damages of any kind caused by uses for which this product was not designed, intended, or tested by Ametek.

AMETEK

CHEMICAL PRODUCTS DIVISION • 900 GREENBANK ROAD, WILMINGTON, DE 19808
TELEPHONE: (302) 995-0400 FAX: (302) 995-0491 TELEX: 83-5347
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AMETEK CHEMICAL PRODUCTS DIVISION

SILTEMP

HIGH TEMPERATURE TEXTILES

SILTEMP 84CH AND SILTEMP 188CH

Product Description

Siltemp® is the most widely recognized name in the High Temperature Textile Market, and for over 20 years has been the preferred choice in the protection of equipment and personnel in high temperature applications. **Siltemp 84CH and Siltemp 188CH** are silica fabrics that can withstand molten metal temperatures and can protect personnel and equipment at **continuous temperatures up to 1,800°F (1,000°C).** Siltemp 84CH and 188CH can be used or fabricated as **welding drop cloths, stress relief blankets, protective screens/covers, furnace curtains, insulation mats and cable tray wraps.** Siltemp fabrics are used extensively in the Power Generation, Refinery, Construction, Shipbuilding, and Metal Processing industries.

Features

- Resists Penetration Of Weld "Slag" And Passes Welding "Burn Through" Test
- Fireproof
- Excellent Insulating Properties
- Easily Sewn And Fabricated
- High Strength And Flexibility

Benefits

- Protects Equipment And Personnel In The Toughest Welding Applications
- Protects Against Hot Work Fires
- Lower Utility Costs
- Wide Product Variety (Blankets, Curtains, Mats...)
- Multiple Product Use - Cost Effective

Technical Data

Properties	Siltemp 84CH	Siltemp 188CH
Silicon Dioxide Content	96% Or Greater	96% Or Greater
Nominal Weight (oz/yd^2)	18	36
Nominal Thickness (inches)	0.030	0.054

Notes:

1. Roll length is 50 yards, and roll width is 36 inches. Other roll lengths are available.
2. Siltemp fabrics can meet Military Specs MIL-C-24576A and MIL-I-24244C upon request.
3. A light hydrocarbon coating is applied for improved handling at low temperatures.
4. Siltemp fabrics are amorphous silica textiles, and contain no asbestos or ceramic fibers.

Product Bulletin #HTT-025
Rev. 1/6/98

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AMETEK CHEMICAL PRODUCTS DIVISION

HIGH TEMPERATURE TEXTILES

SEWING TIPS FOR SILTEMP AND ULTISIL FABRICS

These tips are intended to provide fabricators with helpful information for sewing Siltemp and Ultisil fabrics.

NEEDLES

The needle size range should be 16 to 18 gauge, and the needle should be a **ball point** style. Large diameter needles damage fabrics by breaking the yarns. Select the largest needle that does not damage the fabric.

THREAD

Thread diameter should be 0.016 to 0.021 inches. Small diameter threads will cut Siltemp fabric when tensioned for stitching. Correct thread diameter is the thickest thread that can be used without being damaged by a given needle size. Choice of thread material depends on the application temperature requirement. Fiberglass (w/16 to 18% Teflon coating) and Kevlar sewing threads perform well at intermediate temperatures (to 800°F). For high temperature applications where the environment is not electrically conductive, a jacketed stainless steel thread can be used.

STITCH

There should only be 5 to 7 stitches per inch. Use care to stay within recommended range. A larger number of stitches can significantly reduce the seam strength.

SEWING MACHINE FOOT PRESSURE

Set the machine pressure medium to heavy. Low pressure will cause uneven stitch length, and allow the feed dog to abrade the fabric by partially sliding over it. Heavy foot pressure will also cause fabric abrasion.

SEWING THREAD TENSION

Select a balanced upper and lower tension for firm stitching. Loose stitches do not form a strong seam and may be severely damaged by any slight abrasion. Tight stitches may cause seam failure by cutting into the fabric.

CURTAIN & BLANKET FABRICATION

SEAMS

Make all seams 1" wide and secure with two lines of stitches. Recommended seam style is a lock seam with the first stitch line going through three layers of Siltemp, and a second line of stitches going through four layers.

HEMS

Hem all outside edges of the curtain. Turn all edges including the cloth selvage, or feathered edge, under the hem, and stitch with two lines of stitches so that both the hem proper and the "turned under" edge are secure. To ensure a top quality blanket, Ametek would also recommend that 2" Siltemp Woven Tape be sewn into each hem. All edges are turned under the tape before sewing.

STITCH LINES

Do not run stitch lines over the edge of the hem, or back stitch close to the edge. This practice will cause weaknesses in the cloth. Stitch line stops can be made by ending the line in a triangle pattern.

GROMMETS

Secure a heavy flat grommet through at least three layers of Siltemp. When light metal grommets are used, do not crimp the grommet so tightly that the Siltemp is cut under the grommet washer. The Siltemp cloth can be protected by putting a leather washer between Siltemp and the grommet before crimping.

Technical Bulletin #HS-105
Rev. 4/30/97

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HAVEG DIVISION

SILTEMP®
FABRIC-CH
THERMAL BARRIER

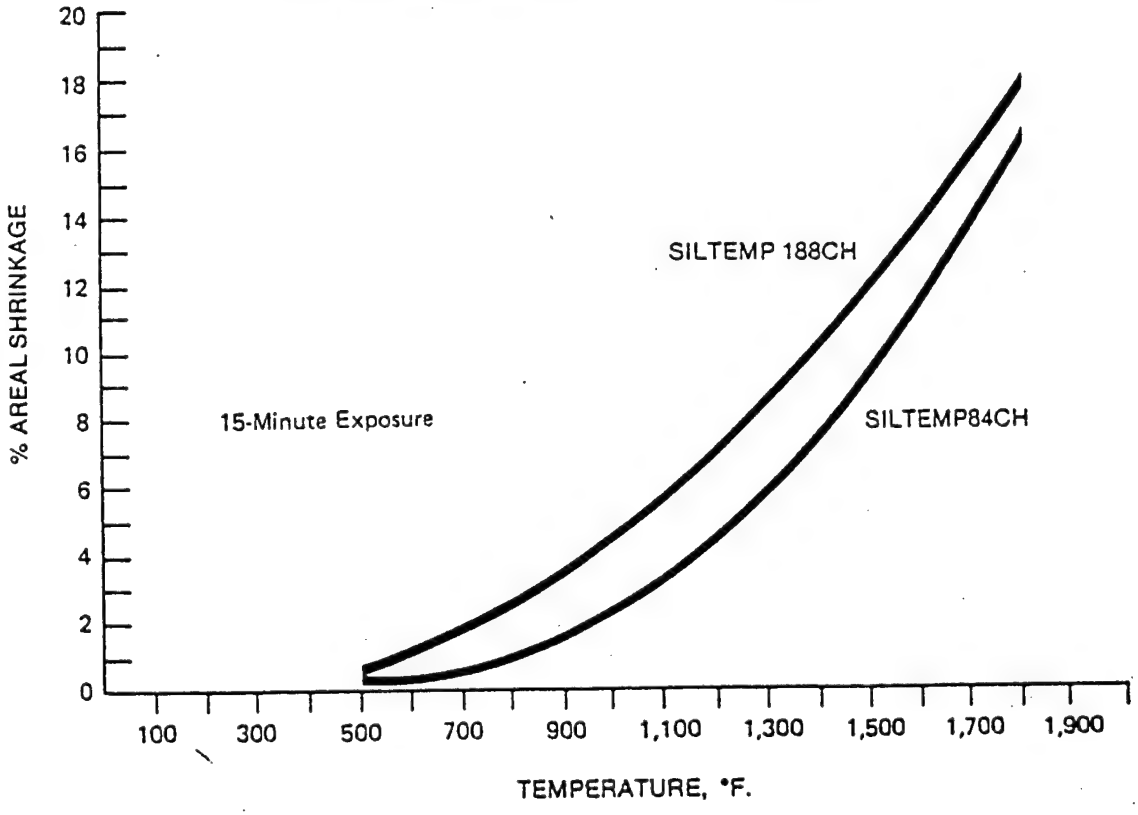
TECHNICAL
BULLETIN HS-116
JANUARY, 1984

CONTAINS NO ASBESTOS

FOR HIGH-TEMPERATURE INSULATION

SILTEMP® is a family of flexible high-silica textiles with outstanding thermal resistance. SILTEMP is similar to refractory material and does not melt until temperatures exceed 3000°F.

TYPICAL AREAL SHRINKAGE—
SILTEMP 84CH AND SILTEMP 188CH



HAVEG

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We cannot anticipate all conditions under which this information and our products, or the products of other manufacturers in combination with our products, may be used. Users are advised to make their own tests to determine the safety and suitability of each such product or product combination for their own purposes.

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AMETEK CHEMICAL PRODUCTS DIVISION

HIGH TEMPERATURE TEXTILES

CHEMICAL COMPOSITION OF AMETEK HIGH TEMPERATURE TEXTILES

Element	Chemical Nomenclature	Percent Composition (%)
Silicon Dioxide	SiO_2	97.85
Titanium Dioxide	TiO_2	0.80
Aluminum Oxide	Al_2O_3	0.71
Calcium Oxide	CaO	0.23
Magnesium Oxide	MgO	0.17
Boric Oxide	B_2O_3	0.16
Sodium Oxide	Na_2O	0.03
Iron Oxide	Fe_2O_3	0.01
Zirconium Oxide	ZrO_2	0.01
Chromium Oxide	Cr_2O_3	<0.01
Copper Oxide	CuO	<0.01
Nickel Oxide	NiO	<0.01

Notes:

1. Typical chemical composition of base silica fabric through emission spectrograph analysis.

Technical Bulletin #HS-114
Rev. 4/30/97

Ametek cannot predict all of the potential applications for which customers may attempt to use High Temperature Textile products. High Temperature Textile products will have varying degrees of effectiveness for each potential application depending on the maximum temperature attained, the length of use, and the amount of temperature fluctuation. If the customer has any questions regarding the use of Ametek High Temperature Textile products in a particular application, please contact Ametek Chemical Products Division at (302) 995-0400 and we will provide a sample for testing. This product is not warranted against injuries or damages of any kind caused by uses for which this product was not designed, intended, or tested by Ametek.

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AIR PERMEABILITY

Periodically, questions regarding air flow through Siltemp and Ultisil have been asked. In some instances, expansion joints for one, low to no air flow is desirable. In a few cases, high air flow is necessary. Tests were run according to ASTM D737-75 which measures air flow in cubic feet per minute per square foot of surface (CFM/ft.^{2}) at a pressure differential between the two surfaces of the fabric of 0.5 inches (12.7 mm) of water (2.6 lbs./sq.ft.). It should be noted that air permeability is not a linear function of the pressure differential.

Fabric		Air Flow CFM/ft.^{2}
Siltemp	84CH	30
	188CH	14
	84S	9
	188S	6
Ultisil	HT84CH	18
	HT188CH	10
	HT84SH	13
	HT188SH	6

AMETEK
HAVEG DIVISION

FABRIC-CH-SR
THERMAL BARRIER

PRODUCT
BULLETIN
HS-118
JULY 1992

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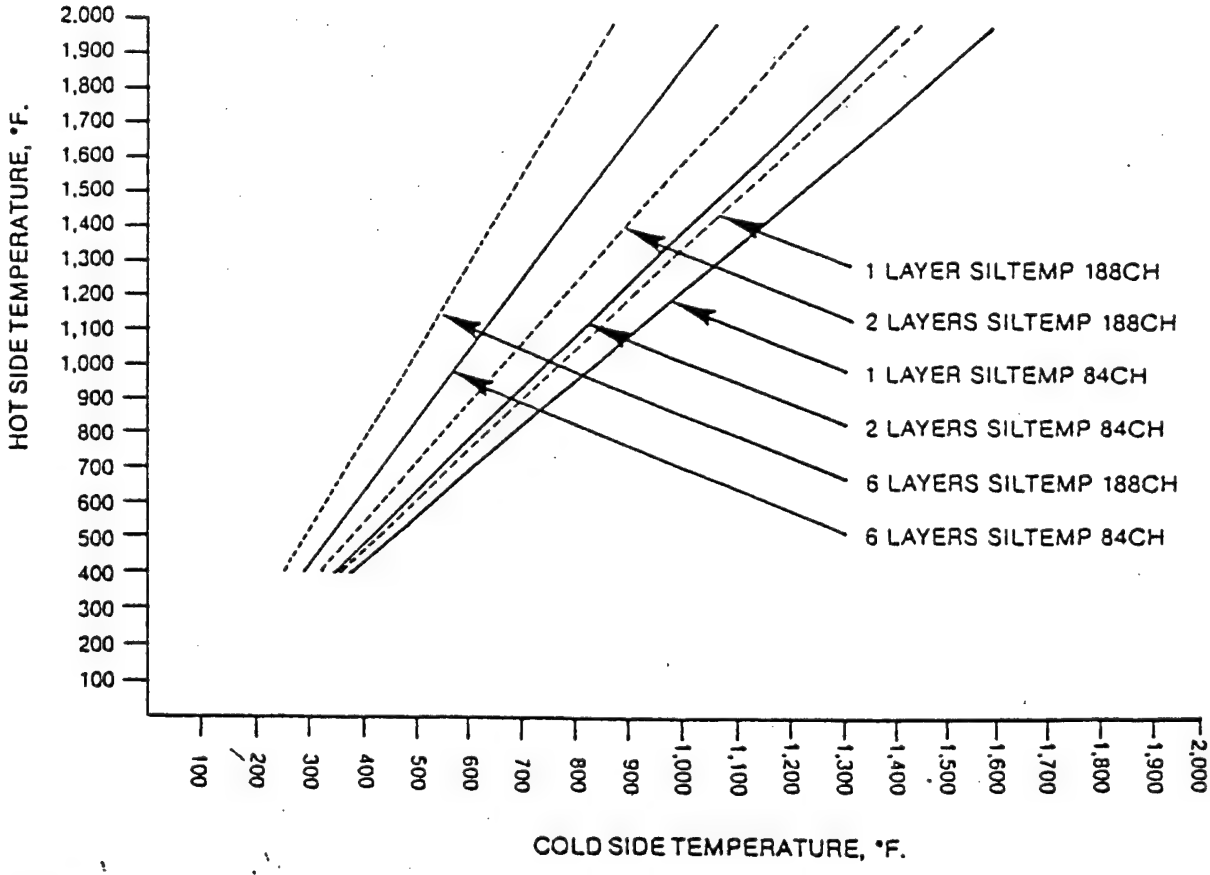
FOR HIGH-TEMPERATURE INSULATION

SILTEMP® is a family of flexible high-silica textiles with outstanding thermal resistance. SILTEMP is similar to refractory material and does not melt until temperatures exceed 3000°F.

TYPICAL HOT SIDE/COLD SIDE DATA—



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SILTEMP®
FABRIC-CH-SR
THERMAL BARRIER

TECHNICAL
BULLETIN
HS-117

JULY 1992

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FOR HIGH-TEMPERATURE INSULATION

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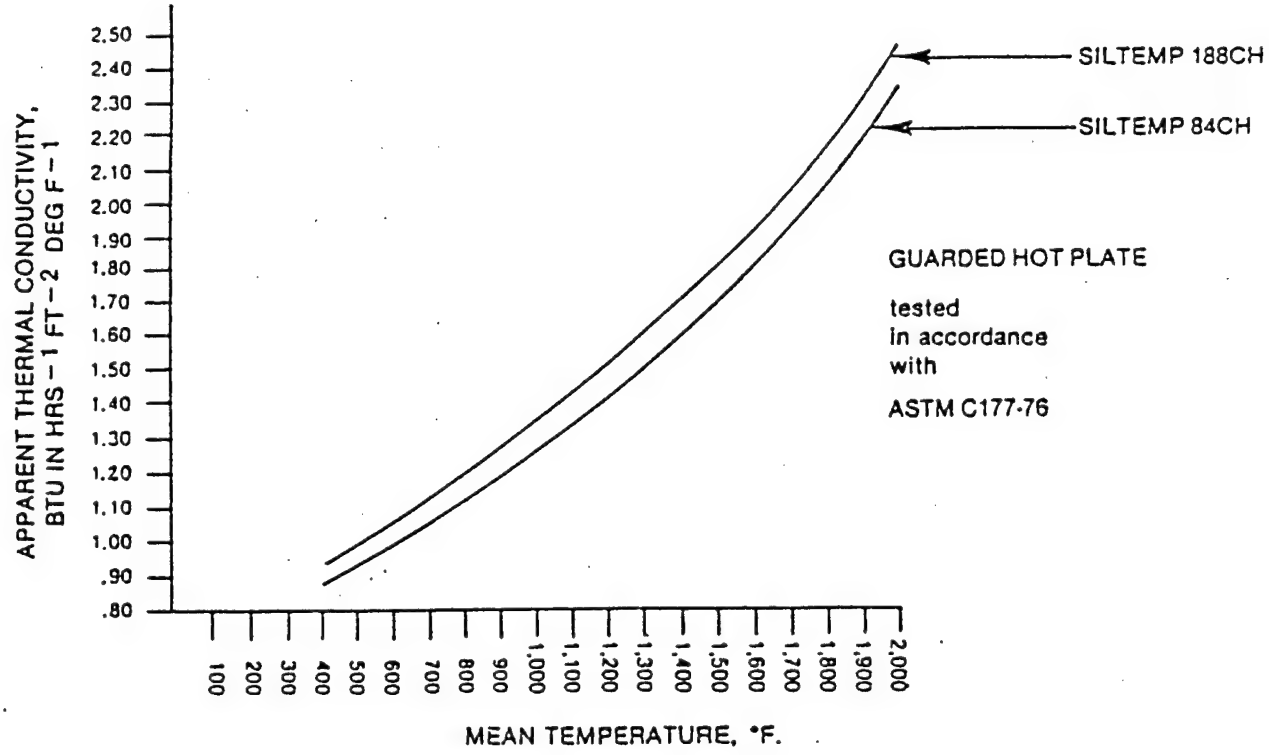
TYPICAL APPARENT THERMAL CONDUCTIVITY



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TELEPHONE: (302) 995-0400
TELEX: 83-5347

MAY BE USED TO COMPLY WITH OSHA'S
HAZARD COMMUNICATION STANDARD.
29 CFR 1910.1200. STANDARD MUST BE
CONSULTED FOR SPECIFIC REQUIREMENTS.

MATERIAL SAFETY DATA SHEET - NON-MANDATORY FORM

IDENTITY: - SILTEMP FABRIC
84CH, 100CH, 36CH, 188CH, 136CH

SECTION 1

Manufacturers Name:
Ametek, Inc.
Chemical Products Division

Address:
900 Greenbank Road
Wilmington, Delaware 19808

Emergency Telephone Number: (302) 995-0496

Information Telephone Number: (302) 995-0400

Date Prepared: October 1996

SECTION 2 - HAZARDOUS INGREDIENTS INFORMATION

Hazardous Components:	OSHA PEL:	ACGIH TLV:	%(OPTIONAL):
Amorphous Silica (CAS #7631-86-9)	*	10mg/m^3	96

*OSHA has not established a specific PEL for fibrous silicon dioxide materials such as Siltemp. Chemically Siltemp is amorphous silica which has an OSHA limit of 80mg/m^3.

SECTION 3 - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point: N/A

Specific Gravity: 2.2

Vapor Pressure: N/A

Melting Point: >3,000° F

Vapor Density: N/A

Evaporation Rate: N/A

Solubility in Water: Not Soluble

Appearance and Odor: Off-White/Tan Colored, No Odor

SECTION 4 - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A Flammable Limits: LEL: N/A UEL: N/A

Extinguishing Media: Water, foam, carbon dioxide, or dry chemical as suitable for type of surrounding fire.

Special Fire Fighting Procedures: Use self-contained breathing apparatus in a sustained fire.

Unusual Fire and Explosion Hazards: None known

SECTION 5 - REACTIVITY DATA

Stability: Unstable Conditions to Avoid: None Known

Stable X

Incompatibility (Materials to Avoid): Basic phosphates, hydrofluoric acid and some oxides and hydroxides

Hazardous Decomposition or By-Products: Thermal decomposition of any small amount of coating may produce carbon monoxide and carbon dioxide.

Hazardous Polymerization: May Occur Conditions to Avoid: None Known

May Not Occur X

SECTION 6 - HEALTH HAZARD DATA

Route(s) of Entry	Inhalation	Skin	Eyes	Ingestion
	X	X	X	Not likely to occur

HEALTH HAZARDS

ACUTE:

Ingestion: Not a normal route of exposure. May cause temporary irritation of disgestive tract. If symptoms develop, contact a physician.

Skin Contact: May produce temporary irritation of skin when coming in contact with skin.

Eye Contact: Fibers and dusts may cause temporary irritation to the eyes.

Inhalation: Inhalation of fibers may cause irritation to the mouth, nose, and throat.

CHRONIC:
There are no known health affects associated with chronic exposure to this product.

Carcinogenicity:

Hazardous Ingredients:	Listed as carcinogen by: ACGIH	IARC	NTP	OSHA
Amorphous Silica	No	No	No	No

Signs and Symptoms of Exposure:
Eye, skin, throat, and nose irritation may occur.

Medical Conditions Aggravated by Exposure:
Persons with pre-existing skin and respiratory disorders may be more susceptible to the effects of exposure to this material.

Emergency First Aid Procedures:
Ingestion: Seek medical attention for digestive tract symptoms.

Skin Contact: Wash contacted area of skin thoroughly with mild soap and cool water. Using a skin cream after washing may reduce irritation. Seek medical attention if irritation persists.

Eye Contact: Flush eyes immediately with running water for at least 15 minutes. Seek medical attention if irritation persists.

Inhalation:
Remove person from source of exposure. Seek medical attention if irritation persists.

SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE

Spill or Leak Procedure: N/A

Waste Disposal Method:
The transportation, storage, treatment, and disposal of this waste material must be performed in compliance with all applicable Federal, State, and local regulations.

Precautions to be Taken in Handling and Storing:
Store in a clean, dry place and keep containers closed.

a erial which has been subjected to elevated temperatures (>1800°F) may nuergo partial conversion to cristobalite, a form of crystalline silica, which ay cause respiratory illness. The amount of cristobalite present will depend n he temperature and length of service. The OSHA permissible exposure limit P L) for cristobalite is 0.05 mg/m^3 (resp.).

a icular care should be taken when working with "used" material to minimize u t. If exposure limits are exceeded or if irritation is experienced, NIOSH pproved respiratory protection should be worn.

E TION 8 - CONTROL MEASURES

e iratory Protection:
s a NIOSH approved disposable dust respirator such as 3M Model 8710 or quivalent when high dust levels are present or the level of fibers exceeds he OSHA permissible exposure limits.

entilation:
en ral ventilation and/or local exhaust ventilation should be utilized to e tain exposures below the PEL's or TLV's. When material is used at elevated e peratures, adequate ventilation must be available.

y Protection:
a ety glasses with side shields or chemical splash goggles must be worn to revent eye contact. A safety eyewash station should be readily available near he work area.

r tective Clothing:
ea rubber gloves when handling the product. Personnel that are more u eptible to irritation from fibers or dusts should wear full-body coveralls.

ork/Hygienic Practices:
s good personal hygiene. Use of protective creams before handling the a erial may prove beneficial.

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e cannot anticipate all conditions under which this information and u products, or the products of other manufacturers in combination with u products, may be used. Users are advised to make their own tests to e ermine the safety and suitability of each such product or product ombination for their own purposes.

3306 Oak Gardens Dr.
Kingwood, TX 77339
Phone/Fax 281-359-7150

Ametek,

Chemical Products Div.

October 5, 1998

Parsons Engineering Sciences, Inc.
1700 Broadway Suite 900
Denver CO 80290

Dear Mr. Bondarewicz,

Thanks for saving me the traffic snarls of Denver and for sharing with me the SILTEMP application for the Thermal Oxidation System.

The 1200 Sq. feet of area you will protect is only 2.6 rolls of Siltemp 84CH for the horizontal cover and assuming a 40ft. wide room by 10 ft. ceiling and a nominal roof peak I believe 1.25 rolls of fiberglass will provide the curtain wall.

I suggest you consider using Siltemp all the way, to avoid possible confusion with the two different materials and to make the Curtain Wall a Secondary FIREPROOF wall in large rooms and reduce the waste of partial use of roll goods .

PRODUCT	PRICE, per yard
Siltemp[R] 84CH 18 oz./sq. yd., 36 in. nom. width, 0.03 in. nom. thickness	$21.25
Haveglas[™] HT26H 26 oz. /sq. yd., 38 in. nom. width, 0.035 in. nom. thickness	$15.50

FOB Wilmington, DE From stock .

Please contact me if you need additional data , 281-359-7150 or to place an order contact Kathy Thomas at 1-800-441-7777 x566.

Sincerely,

Carl J. Stier

Regional Sales Manager

CC: K. Thomas

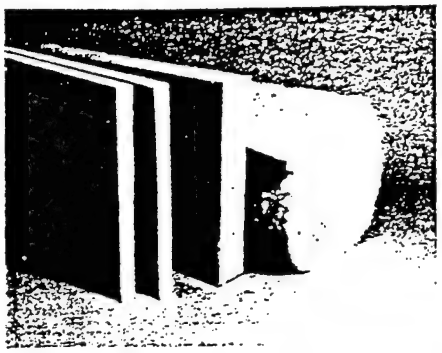
SCHULLER

High Temperature Fiber Glass Board/Blanket Insulation

☐ 1000 Series Spin-Glas

☐ Precipitator Spin-Glas

☐ HTB 26 ☐ HTB 23



INFO SPEC

Submittal Sheet

1000 Series Spin-Glas®

Type: Board Insulation
Temp. Limit: 850°F (454°C)

Description
1000 Series Spin-Glas is a 3.0 pounds per cubic foot (48 kg/m³), semi-rigid board produced by a unique felting process that combines Spin-Glas fiber and controlled amounts of organic binder into an insulation with superior handling properties and insulating effectiveness at minimum cost.

Applications
For insulating furnaces, boilers, heated vessels, ducts, tanks and other heated equipment operating at temperatures up to 850°F (454°C).

Available Sizes
Furnished in board form only in thicknesses from 1" to 4" (25 mm to 102 mm) in ½" (13 mm) increments. Standard sizes available are 24" x 48", 24" x 96" and 48" x 96" (0.61 m x 1.22 m, 0.61 m x 2.44 m and 1.22 m x 2.44 m). Other sizes are available on special order.

Advantages
High Strength. Because of its unique fiber orientation and the latest advances in binder technology, 1000 Series Spin-Glas exhibits excellent handling properties during shipping and installation and can stand up to the rigors of heavy vibration when in use.

Easy Application. The firm, lightweight structure of this board makes possible the impaling of insulation directly on studs or clips, and permits use of labor saving larger batt sizes.

Full Size Range. Wide variety of standard sizes eliminates trimming during installation, reducing application costs.

Precipitator Spin-Glas®

Type: Board Insulation
Temp. Limit: 850°F (454°C)

Description
Precipitator Spin-Glas is a 2.4 pounds per cubic foot (38.45 kg/m³), semi-rigid, lightweight felted board composed of fine rotary process fibers bonded with a special organic resin. Density, binder content and thickness are carefully controlled to assure full insulating value and strength.

Applications
Specifically designed for insulating precipitators, ducts and breechings in power generation plants. Also suited for boilers and other industrial equipment up to 850°F (454°C).

Available Sizes
Furnished in thicknesses from 1" to 4" (25 mm to 102 mm) in ½" (13 mm) increments; lengths of 48" and 96" (1.22 m and 2.44 m) available in 12" and 24" (305 mm and 610 mm) widths. Other sizes are available on special order.

Advantages
Superior Strength. Precipitator Spin-Glas Insulation, with long fibers uniformly distributed and held by an organic binder, is resilient, strong, shot-free and highly resistant to damage in shipping, handling, and installation. Highly resistant to damage from vibration.

Simple Installation, Low Installed Cost. Has a clean,"friendly" feel and is substantially lighter in weight than many mineral wools with comparable thermal performance. Adaptable to flat or curved surfaces, easy to make tight butt joints; easy to cut and shape around obstructions. May be installed using pins, wire, mesh, or in prefabricated panels. Experienced mechanics can install more boards in the same period of time.

HTB 26, HTB 23 Spin-Glas®

Type: Blanket Insulation
Temp. Limit: 1000°F (538°C)

Description
Spin-Glas HTB is a lightweight, off white insulation blanket designed to provide high insulating efficiency for industrial applications.

Depending on the application, Spin-Glas HTB is available in two densities:

	Density	
Type	pcf	kg/m³
HTB 26	1.06	17
HTB 23	2.00	32

Applications
Spin-Glas HTB Insulation was developed specifically for use in various appilcations requiring a low density blanket up to 1000°F (538°C). This flexible blanket insulation is particularly suitable for heated irregular surfaces.

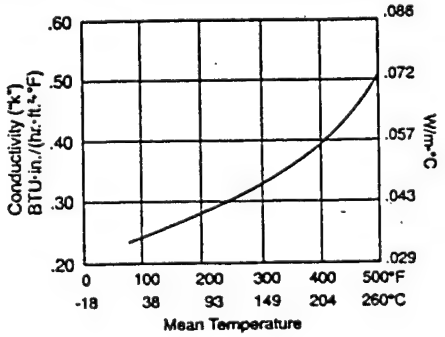
Available Sizes
Widths: 24", 36", 48" (0.61 m, 0.92 m, 1.22 m)

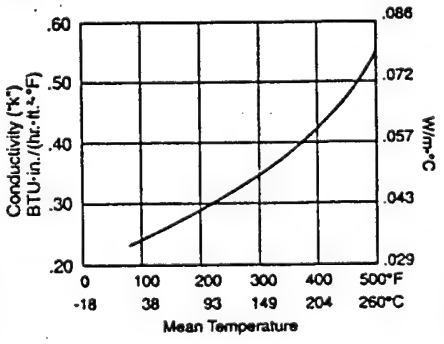
		Type			
		HTB 26		HTB 23	
Thickness		Length		Length	
(in)	(mm)	(ft)	(m)	(ft)	(m)
1"	25	100*	30.5*	100*	30.5*
1½	38	100	30.5	75	22.9
2	51	100	30.5	50	15.3
3	76	75	22.9	—	—
4	102	50	15.3	—	—

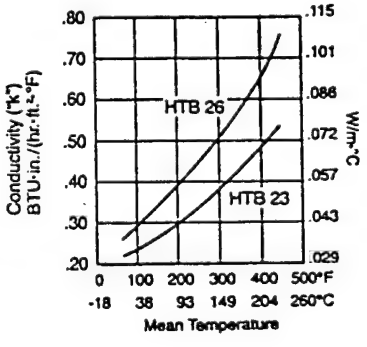
*Supplied double thick for 200 ft (61 m) per package.

Packaging
Rolls. Compression packed in vac pak consisting of a poly tube with an outer restraining sleeve. Cardboard cores will be provided only at customer request.

Thermal Conductivity (ASTM C 518)







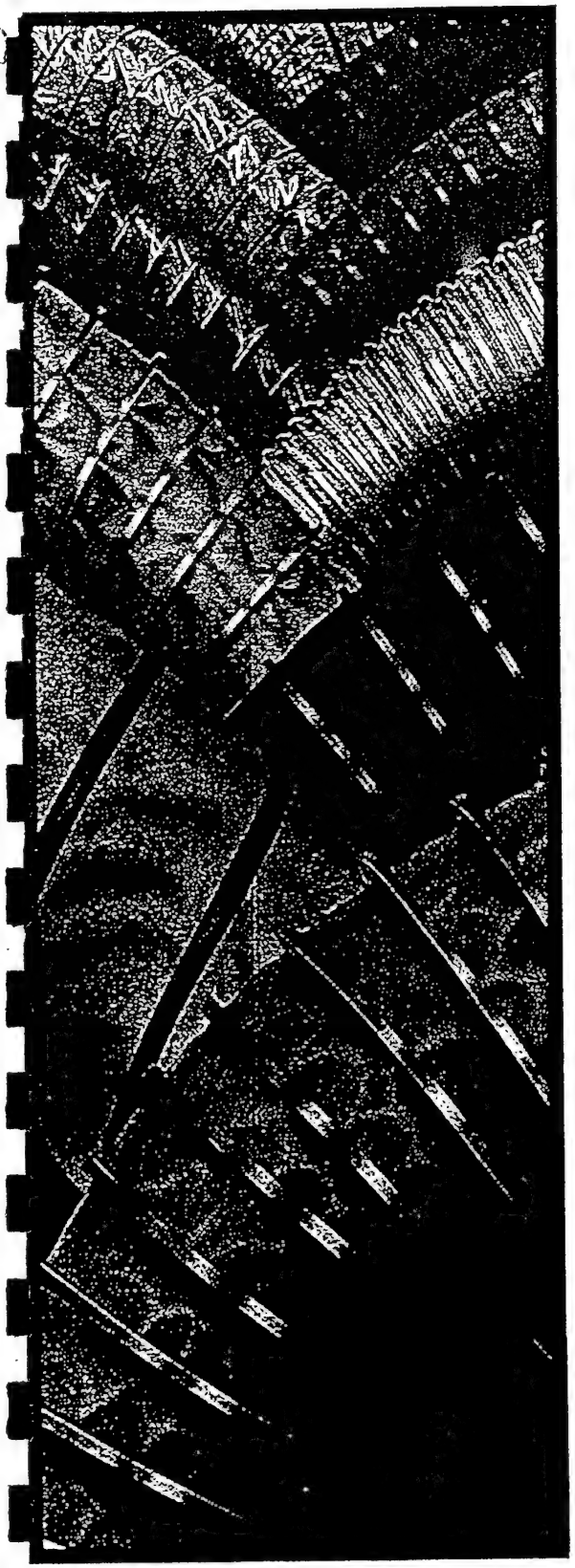
COMPETITIVE PRODUCT COMPARISON

MANUFACTURER	SCHULLER	OWENS-CORNING	KNAUF	CERTAINTEED
PRODUCT NAME	1000 SERIES	INSUL-QUIK	ET BOARD	850F BOARD
FIBER TYPE	ROTARY	ROTARY	ROTARY	ROTARY
TEMPERATURE LIMIT	850F(6"MAX)	850F(950 AFTER 24HR)	850F(6"MAX)	850F
FIRE HAZARD CLASS.	25/50	25/50	25/50	25/50
DENSITY	3	3	2.8	3
"k" FACTOR @ 300F MEAN	.33	.37	.38	.42
THICKNESS (INCHES)	1-4	1-4	1-4	1-4
SIZES (INCHES) STD.	24X48	24X48	24X48	24X48
PACKAGING	POLY	PE-PAC	SLEEVE/CTN	CTN
PLANT LOCATIONS	CLEBURNE, TX.	NEWARK, OH.	SHELBYVILLE, IN	MOUNTAINTOP, PA

MANUFACTURER	SCHULLER	OWENS-CORNING	KNAUF	CERTAINTEED
PRODUCT NAME	PRECIPITATOR	TIW TYPE II	ET PANEL	HT BLKT-TYPE II
FIBER TYPE	ROTARY	ROTARY	ROTARY	ROTARY
TEMPERATURE LIMIT	850F(6"MAX)	1000F	1000F	1000F
FIRE HAZARD CLASS.	25/50	25/50	25/50	25/50
DENSITY	2.4	2.4	2.4	2.4
"k" FACTOR @ 300F MEAN	.34	.40	.41	.35
THICKNESS (INCHES)	1-4	1-4	1-4	1-4
SIZES (INCHES) STD.	24X48	24,36,48X48	24X48,24X96	24X48
PACKAGING	POLY	TUBE	SLEEVE	CTN
PLANT LOCATIONS	CLEBURNE, TX.	NEWARK, OH.	SHELBYVILLE, IN	MOUNTAINTOP, PA

MANUFACTURER	SCHULLER	OWENS-CORNING	KNAUF	CERTAINTEED
PRODUCT NAME	HTB 26	TIW TYPE I	ET BLANKET	HT BLKT-TYPE I
FIBER TYPE	ROTARY	ROTARY	ROTARY	ROTARY
TEMPERATURE LIMIT	1000f	1000F	1000F	1000F
FIRE HAZARD CLASS.	25/50	25/50	25/50	25/50
DENSITY	1.06	1.0	1.0	1.0
"k" FACTOR @ 300F MEAN	.5	.55	.53	.53
THICKNESS (INCHES)	1-4	1-4	1.5-4	1-4
SIZES (INCHES) STD.	24X100LF	24X76LF	24X75LF	24X75LF
PACKAGING	POLY TUBE	TUBE	TUBE	TUBE
PLANT LOCATIONS	CLEBURNE, TX.	NEWARK, OH.	SHELBYVILLE, IN	MOUNTAINTOP, PA

MANUFACTURER	SCHULLER
PRODUCT NAME	HTB 23
FIBER TYPE	ROTARY
TEMPERATURE LIMIT	1000f
FIRE HAZARD CLASS.	25/50
DENSITY	2.0
"k" FACTOR @ 300F MEAN	.38
THICKNESS (INCHES)	1-4
SIZES (INCHES) STD.	24X100LF
PACKAGING	POLY TUBE
PLANT LOCATIONS	CLEBURNE, TX.



Uni-flex

Industrial Ducting and Hose

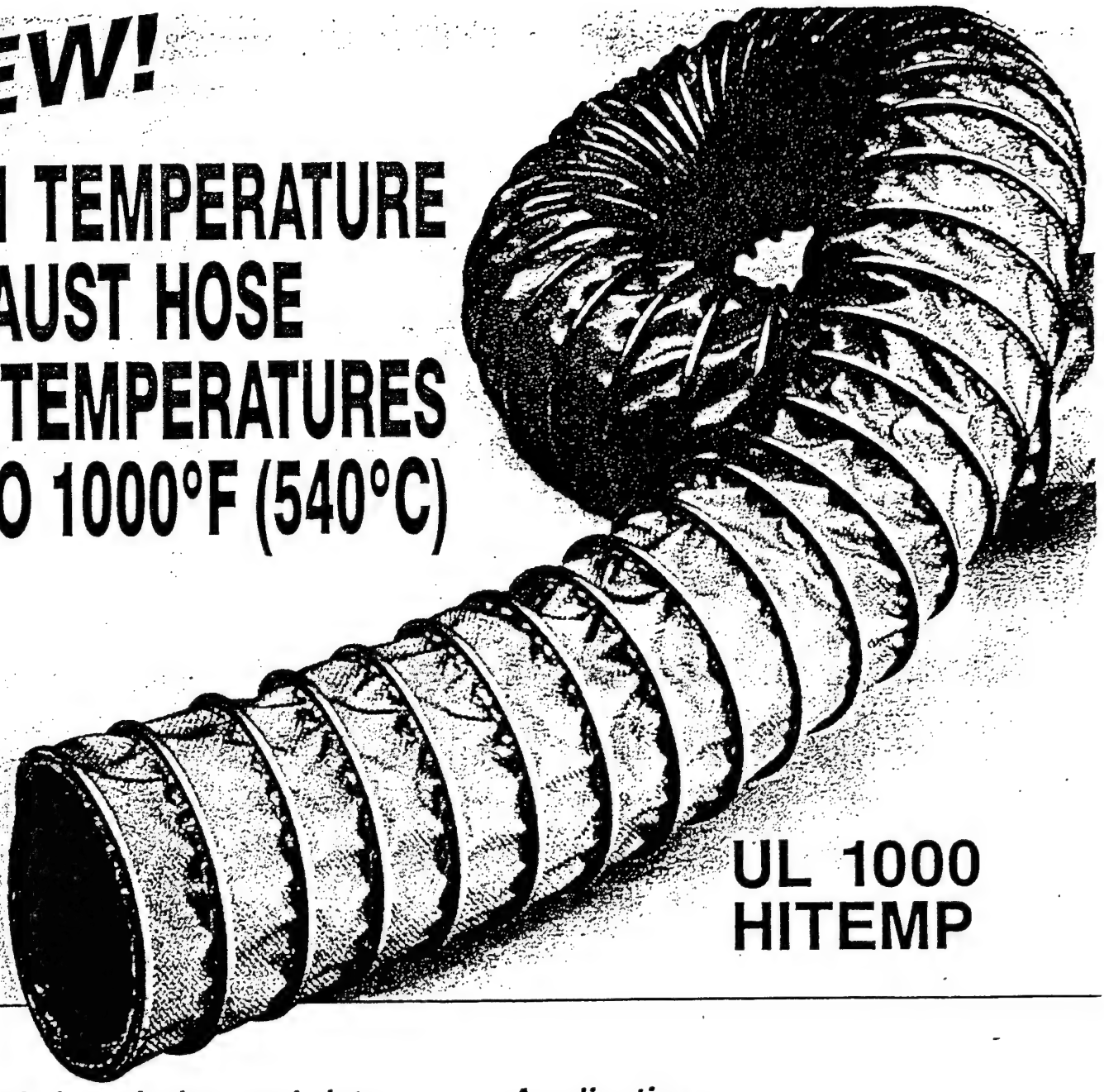
Price Guide
Effective September 1, 1995

Uni-flex Inc.
1024 Industrial Drive
Berlin Twp., NJ
08009

Phone: (609) 768-2275
Fax: (609) 768-2385
Call Toll Free
1-800-225-0215

NEW!

HIGH TEMPERATURE EXHAUST HOSE FOR TEMPERATURES UP TO 1000°F (540°C)



UL 1000 HITEMP

Technical description and data:

The UL 1000 High Temperature Hose is highly flexible, lightweight, asbestos-free and reinforced with fine V4A wire for added strength. Before coating the hose is treated with a special chemical which increases its resistance to high heat. The external steel wear strip provides maximum protection against scuffing. The UL 1000 hose is non-flammable and environmentally safe because it is silicone free and non-toxic.

Compressibility: To 25% of the ordered length.

Service temperature: −200° to 1000°F (−130° to 540°C); can briefly withstand up to 1380°F (750°C).

Sizes: Standard lengths 25'. Special lengths on request. Hose diameters 3" to 24".

Color: Silver grey.

Subject to technical changes and color deviations.

Resistance:

Resistant to all combustion exhausts.

Applications:

For extracting engine exhaust fumes for dynamometers and other high-performance tests in the automotive, diesel and defence industries. Also used in general engine construction, furnace construction, iron and steel works, and as a heat shield or compensator.

Installation:

Quick and easy using the bridge clamp.

Fm Uni-flex™

A Division of Z-FLEX US, Inc.

21 Elbo Lane
Mt. Laurel, NJ 08054
(609) 866-0590
Toll free: 1-800-225-0215

20 West Pearce Street
Richmond Hill, Ontario
L4B 1E3
(416) 731-9411

U-nova

U-LOK 1000

SERVICE CONDITIONS

This highly flexible duct is constructed of asbestos free special fabric. Very fine V4A wire provides additional woven-in reinforcement. Chemical treatment followed by coating provides higher heat resistance.

- *High temperature fume recovery*
- *Scuff resistant*
- *Flame resistant*
- *Air Velocity should be less than 50 m/sec.*
- *Not recommended for diesel fume applications*

MATERIAL	Asbestos-free fabric reinforced with fine V4A wire. Coated with E-Glass
CONSTRUCTION	Mechanical bond, stainless steel helix
SIZE	3" to 24" I.D. Larger sizes available
STANDARD LENGTH	25ft
WEIGHT	6" I.D. =1.01 lbs/ft
TEMPERATURE RANGE	Minus 200°F to 1000°F
COMPRESSION RATIO	3"-4" =4:1

web site: u-nova.com email: sales@u-nova.com

EIGHT LOCATIONS TO SERVE YOU

Richmond Hill, Ontario
(905) 731-9411

Whitby, Ontario
(905) 666-4970

Etobicoke, Ontario
(416) 679-0045

Ottawa, Ontario
(613) 744-7360

Calgary, Alberta
(403) 277-3115

Delta, British Columbia
(604) 940-6401

Pointe Claire, Quebec
(514) 697-3701

West Berlin, N.J. USA
(609) 768-2275

UNI-FLEX
HIGH TEMPERATURE SERVICE

PRODUCT	U-LOK 1000	U-LOK 1011	U-LOK 1015
COATING		U-LOK 1000 INSIDE	U-LOK 1011
FABRIC	HI TEMP GLASS	TEFLON COATED FIBERGLASS OUTSIDE	WITH CERAMIC FILLER
COLOR	SILVER	GREY	GREY
TEMP RANGE	-200°F to +1,000°	-200°F (inside) to +700°F Intermittent (outside)	-200°F (inside) to +750°F (outside)
ID	PRICE/FT	PRICE/FT	PRICE/FT
3"	26.79	44.60	49.50
4"	39.67	62.80	70.00
5"	48.08	76.00	84.50
6"	58.38	92.80	103.00
7"	60.10	112.00	124.70
8"	64.57	132.00	146.00
9"	73.84	154.00	172.00
10"	82.42	168.00	186.00
12"	91.70	204.00	220.00
14"	116.86	238.00	264.00
16"	130.51	272.00	288.00
18"	144.24	306.00	324.00
20"	151.11	340.00	360.00
22"	178.59	375.00	396.00
24"	199.19	N/A	N/A

PRICES SUBJECT TO CHANGE WITHOUT PRIOR NOTICE
MINIMUM BILLNG LENGTH 10' NON STANDARD LENGTHS - ADD 10%
MINIMUM INVOICE TOTAL $75.00 (EXCLUDING FREIGHT)
F.O.B. MANUFACTURING PLANT

If you're going to drag it, be sure to 'Clip' it!

Design Considerations

Fiberglas® All-Service Duct Wrap

Application Recommendations

Before applying All-Service duct wrap, sheet metal ducts shall be clean,dry, and tightly sealed at all joints and seams.

All-Service duct wrap insulation shall be cut to "stretch-out" dimensions and a 2" (51mm) piece of insulation removed from the facing at the end of the piece of insulation to form an overlapping staple and tape flap, as shown below.

Install duct wrap insulation with facing outside so that tape flap overlaps insulation and facing at other end of piece of duct wrap. Butt insulation tightly. If ducts are rectangular or square, install so that insulation is not excessively compressed at duct corners. Seams shall be stapled approximately 6"(152mm) on center with outward clinching staples. Where a vapor barrier is required,seal with pressure-sensitive tape matching the facing,FRK backing stock, or glass fabric and mastic.Adjacent sections of duct wrap shall be tightly butted with the 2"(51mm) tape flap overlapping.

Where rectangular ducts are 24"(610mm) in width or greater, duct wrap shall also be secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced approximately 18" (457mm) on center (max.),to prevent sagging of insulation.

When applying duct wrap to vertical ducts with any dimension greater than 24"(610mm),call your local Owens Corning Representative for installation recommendations. Where a vapor barrier is required,seal all tears, punctures, and other penetrations of the duct wrap insulation facing with tape or mastic to provide a vapor-tight system.

Fiberglas® 700/AF500 Series Insulations

Application Recommendations

Types 701,702/AF220:Lightweight,unfaced flexible insulation in board form for use on vessels having irregular surfaces, where the compressive strength is not a performance criterion.

Types 703/AF530,704/AF545,705:Board insulations usually impaled on welded pins on flat surfaces. They are cut in segments and banded in place on irregular surfaces. Unfaced boards are normally finished with reinforced insulating cement or weatherproof mastic.

ASJ or FRK-faced insulation boards shall be applied using mechanical fasteners such as weld pins or speed clips. Fasteners shall be located not less than 3" (76mm) from each edge or corner of the board.Pin spacing along the equipment should be no greater than 12"(305mm) on centers. Additional pins or clips may be required to hold the insulation tightly against the surface where cross-breaking is used for stiffening. Weld pin lengths must be selected to ensure tight fit but avoid "oil-canning."

In multiple-layer applications, use faced material on outer layer only. Cover pins and clips with vapor-sealing,pressure-sensitive patches matching insulation facing. Rub hard with a sealing tool to ensure a tight bond and a vapor seal.

All insulation joints should be sealed with pressure-sensitive joint-sealing tape to match the insulation facing. Rub hard with a sealing tool to effect a tight bond. Recommended practice suggests 3"(76mm) wide tape on flat surfaces or where edges are shiplapped and stapled. Use 5"(102mm) wide tape in lieu of shiplapping.If insulation is being applied to sheet metal duct work, all sheet metal joints should be sealed prior to insulating.

Fiberglas® Pipe and Tank Insulation

Application Recommendations

Measure the length of insulation required according to the fabrication guide located on the carton. Cut completely through the insulation and jacket.Use a flap tool to filet a stapling flange on one end of the insulation.

Each 36" (914mm) section of insulation may be secured around the pipe using staples and mastic or by applying staples and pressure-sensitive vapor-retarder tape. Special care must be taken to vapor sealing of systems operating below ambient temperatures. Adjacent sections should be butted together and then sealed with vapor-retarder tape.

If indoor applications will be painted, use only a water-base latex paint. Outdoor applications require protection against weather.

Fiberglas® Insul-Quick Insulation

Application Recommendations

Insul-Quick insulation is used in panel systems. It is secured to the panel using pins and clips with metal mesh. Panels can be erected flush to heated surfaces or away from them and secured to buckstays or breeching and ductwork angle iron stiffeners.

Insul-Quick insulation can be installed directly to hot flat or curved surfaces. It can be attached using welded pins or studs and finished with sheet metal;or using metal mesh and insulating cement, then canvassed and painted. Pins with speed washers or studs and nuts should be installed on 12"(305mm) x 18"(457mm) centers and the insulation impaled over them. The sheet metal or metal mesh is secured to the same fasteners. Joints of the sheet metal are offset from joints of the insulation.

For temperatures over 400°F (204°C), good practice suggests using double-layer application,regardless of insulation type. Single-layer installation requires good workmanship to minimize heat loss and hot spots at insulation joints.

Design Considerations

Fiberglas® TIW Types I and II Insulations

Application Recommendations

Fiberglas TIW Types I and II insulation can be installed directly on heated flat and curved surfaces by attaching with welded pins or studs and finished with sheet metal or metal mesh and insulating cement,then canvassed and painted.Pins with speed washers or studs and nuts should be installed on 16" (406mm) (maximum) spacing and not more than 4"(102mm) from the edge of the insulation. The insulation is normally impaled over the pins or studs, and the enclosing sheet metal or metal mesh is secured to the same fasteners. Joints of the sheet metal finish are offset from the joints of the insulation.

For temperatures over 400°F (204°C),good insulation practice suggests double- layer application,regardless of insulation type. Single-layer installation of any type of insulation material requires good workmanship to minimize heat loss and hot spots at insulation joints. Fiberglas TIW Types I and II insulation may be installed in either single or multiple layers at all temperatures up to 1000°F (538°C).Maximum allowable thicknesses at that temperature:TIW Type I, 8½" (216mm);TIW Type II,6" (152mm).

High Temperature Industrial Board Insulations

Application Recommendations

Owens Corning High Temperature Industrial Board Insulations cab be installed directly on heated flat surfaces by attaching with welded pins or studs. Unfaced boards may be finished with sheet metal or metal mesh an insulating cement,canvassed and painted.Pins with speed washers or studs and nuts should be installed on 16" (406mm) spacing (max.) and not more than 4" (102mm) from the edge of the insulation. The insulation is normally impaled over the pins or studs and the enclosing sheet metal or metal mesh is secured to the same fasteners. Joints of the sheet metal finish are offset from the joints of the insulation.

With faced insulation boards, cover pins and clips with vapor-sealed pressure sensitive patches matching the FRK facing.

For temperatures over 400°F (204°C),good insulation practice suggests double layer application, regardless of application, regardless of insulation type. Single layer installation of any type of insulation material requires good workmanship to minimize heat loss and hot spots at insulation joints. These insulations may be installed in either single or multiple layers at all temperatures up to 1200°F (649°C).In multiple layer applications, use faced insulation boards on outer layer only.

High Temperature Flexible Batt Insulations

Application Recommendations

Owens Corning High Temperature Flexible Batt Insulations can be installed directly on heated flat and curved surfaces by attaching with welded pins or studs, finishing with sheet metal or metal mesh and insulating cement,canvassed and painted.Pins with speed washers or studs and nuts should be installed on 16" (406mm) spacing (max.) and not more than 4" (102mm) from the edge of the insulation. The insulation is normally impaled over the pins or studs and the enclosing sheet metal or metal mesh is secured to the same fasteners. Joints of the sheet metal finish are offset from the joints of the insulation.

For temperatures over 400°F (204°C),goo insulation practice suggests double layer application, regardless of insulation type. Single layer installation of any type of insulation material requires good workmanship to minimize heat loss and hot spots at insulation joints. These insulations may be installed in either single or multiple layers at all temperatures up to 1200°F (649°C).

Design Considerations

Precautionary Recommendations

Respiratory protection: When the temperature of the surface being insulated exceeds 250°F (121°C), including initial system startup, the binder in these products may undergo various degrees of decomposition depending on the temperature of the application. The need for respiratory protection will vary according to the airborne concentration of the decomposition products released and accumulated in the area. If the insulation is installed on hot surfaces above 250°F (121°C) but below 650°F (343°C),a full-face respirator with cartridges approved for protection against organic vapors (or formaldehyde, if available) should be used.If installing product on surfaces above 650°F (343°C) or during initial system startup where temperatures will exceed 650°F (343°C), a full-face, supplied-air respirator should be used. In areas with good general and/or local exhaust ventilation where exposures are controlled below the formaldehyde, carbon monoxide, and ammonia PEL or STEL, and additive effects have been factored in, then respiratory protection is normally not needed.

Engineering controls: General dilution ventilation and/or local exhaust ventilation should be provided as necessary to maintain exposures below regulatory limits. Dust collection systems should be used in operations involving cutting or machining and may be required in operations using power tools. Additional dilution ventilation may be needed during initial high-temperature startup or after the product is applied to hot surfaces.

Handling: Insulation may cause temporary irritation. Wear long-sleeved, loose-fitting clothing,gloves, and eye protection when handling and applying material. Wash with soap and warm water after handling. Wash work clothes separately, and rinse washer. A disposable mask designed for nuisance-type dusts is advisable where high dust levels are encountered.

Painting: If painting indoor applications with ASJ or FRK jacketing, use only water-base latex paint. Outdoor applications require weather protection.

Caution: Heat may be generated from the resinous binder of insulations if ignited by external sources such as welding slag,cutting torches, etc. Care should be taken to avoid direct contact with the insulation by fire or ignition sources.

NOTES:

Installation recommendations presented are general in nature. Application procedure is at the discretion and responsibility of the design engineer using industry standards and/or Owens Corning recommendations.

It is not usually possible or practical to reinstall these insulation products on pipes or equipment if, after their original installation and exposure to elevated temperatures, they have been removed for any reason.Used insulation products should be properly disposed of.

Refer to the appropriate Material Safety Data Sheet for more information.

Fiberglas® All-Service Duct Wrap

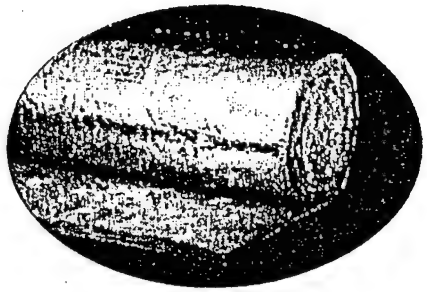
PHYSICAL PROPERTY DATA

Property	Test Method	Specifications
Operating temperature limit	ASTM C 411	250°F (121°C)
Water vaporpermeance	ASTM E 96	0.02 perm maximum
Watervaporsorption	ASTM C 1104	<3% at 120°F (49°C),95% R.H.
Moldorfungusgrowth (mold test)	ASTM C 665	Will not support or promote
Surface burning characteristics	ASTM E 84*	Flame spread,25; Smoke developed,50
Thermal conductivity, k at 75°F mean, Btu•in/hr•ft²•°F	ASTM C 518	Type 75: 0.30 — Type 100: 0.27 — Type 150: 0.25
at 24°C mean,W/m•°C		Type 75: .043 — Type 100: .039 — Type 150: .036
Jacket temperature		150°F (66°C) maximum

AVAILABILITY AND INSTALLED R-VALUES (WIDTH 48" 1219MM)

Nominal Thickness	Out-of-Package R-value*	Installed Thickness**	Installed R-value*
Type 75 – 0.75 pcf (12 kg/m³)			
1½" (38mm)	5.0 (0.9)	1⅛" (29mm)	4.2 (0.7)
2" (51mm)	6.7 (1.2)	1½" (38mm)	5.6 (1.0)
2.2" (56mm)	7.4 (1.3)	1⅝" (42mm)	6.0 (1.1)
3" (76mm)	10.0 (1.8)	2¼" (57mm)	8.3 (1.5)
Type 100 – 1.00 pcf (16 kg/m³)			
1½" (38mm)	5.6 (1.0)	1⅛" (29mm)	4.5 (0.8)
2" (51mm)	7.4 (1.3)	1¼" (38mm)	6.0 (1.1)
Type 150 – 1.50 pcf (24 kg/m³)			
1½" (38mm)	6.0 (1.1)	1⅛" (29mm)	4.8 (0.9)
2" (51mm)	8.0 (1.4)	1¼" (38mm)	6.4 (1.1)

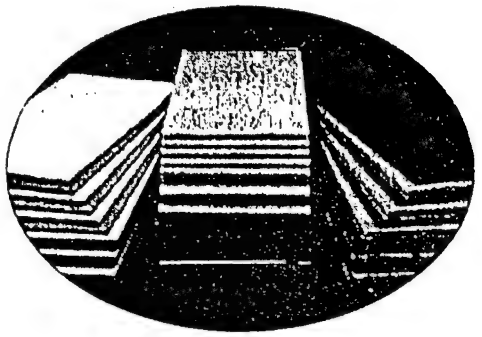
* hr·ft²·°F/Btu (m²·°C/W) **Assumes 25% compression of insulation.



DESCRIPTION

Fiberglas All-Service duct wrap insulation is a blanket of glass fibers factory-laminated to a reinforced foil/kraft laminate (FRK) vapor retarder facing.A 2"(51mm) stapling and taping flange is provided on one edge. This product is designed to meet existing performance standards such as NFPA 90A and 90B and other model building and energy codes.

Fiberglas® 700/AF500 Series Insulations



PHYSICAL PROPERTY DATA

Property	Test Method	Specifications
Operating temperature limit	ASTM C 411	0 to 450°F* (-18°C to 232°C)
Insulation jacket temperature limitation	ASTM C 1136	-20°F to 150°F (-29°C to 66°C)
Jacket permeance	ASTM E 96, Proc A	0.02 perm
Puncture resistance	ASTM D 781	FRK:25 units;ASJ:50 units
Compressive strength (minimum)	ASTM C 165	Type 703/AF530 / Type 704/AF545 / Type 705
at 10% deformation		25 lb/ft² (1197 Pa) / 60 lb/ft² (2873 Pa) / 200 lb/ft² (9596 Pa)
at 25% deformation		90 lb/ft² (4309 Pa) / 225 lb/ft² (10.8 kPa)
Density		Type 701: 1.5 pcf (24 kg/m³) Type 702/AF220:2.3 pcf (37 kg/m³) Type 703/AF530:3.0 pcf (48 kg/m³) Type 704/AF545:4.2 pcf (67 kg/m³) Type 705: 6.0 pcf (96 kg/m³)
Composite surface burning characteristics	UL 723**	Flame spread, 25; Smoke developed,50

*Maximum thickness at 450°F (232°C): Type 701, 702/AF220: 6" (152mm); Type 703/AF530, 704/AF545, 705: 4" (102mm).

Thermal Performance

Insulation Thickness	Operating Temperature							
	200°F (93°C)		300°F (149°C)		400°F (204°C)		450°F (232°C)	
	HL	ST	HL	ST	HL	ST	HL	ST
1" (25mm)	25	98	57	114	95	133	118	143
1½" (38mm)	19	93	40	105	66	119	82	127
2" (51mm)	15	90	30	100	50	111	62	117
2½" (64mm)	12	88	25	96	41	106	51	111
3" (76mm)	10	87	21	94	34	102	41	106
3½" (89mm)	9	86	18	92	30	99	37	103
4" (102mm)	8	85	16	91	26	97	32	101

DESCRIPTION

These insulations are made of inorganic glass fibers with a thermosetting resin binder and formed into flexible, semirigid, or rigid rectangular boards of varying densities. Types 703/AF530,704/AF545,and 705 are available with factory-applied FRK or ASJ facings. Both facings are vapor retarders and provide a neat, finished appearance in mechanical applications.

AVAILABILITY

Fiberglas 700/AF500 Series Insulations are available in standard 24"x 48" (610mm x 1219mm) boards in thicknesses from 1"(25mm) to 4" (102mm) in ½" (13mm) increments. Maximum thickness, Type 705,is 3"(76mm). Types 702/AF220 and 704/AF545 are made-to-order products.

Sound Absorption Coefficients (ASTM C 423)

Mounting Type A:Material placed against a solid backing such as a block wall.

Product Type, Thickness	Octave Bandcenter Frequencies,Hz						
	125	250	500	1000	2000	4000	NRC
701,plain,1"(25mm)	.17	.33	.64	.83	.90	.92	.70
701,plain,2"(51mm)	.22	.67	.98	1.02	.98	1.00	.90
703,plain,1"(25mm)	.11	.28	.58	.90	.93	.96	.70
703,plain,2"(51mm)	.17	.66	1.14	1.07	1.02	.98	1.00
705,plain,1"(25mm)	.02	.27	.63	.86	.83	.95	.65
705,plain,2"(51mm)	.16	.71	1.01	1.01	.99	.99	.95
703 FRK,1"(25mm)	.18	.76	.58	.72	.62	.35	.65
703 FRK,2"(51mm)	.63	.58	.95	.74	.60	.35	.75
705 FRK,1"(25mm)	.27	.66	.33	.66	.51	.41	.55
705 FRK,2"(51mm)	.60	.50	.63	.82	.45	.34	.60
703 ASJ, 1"(25mm)	.17	.71	.58	.68	.64	.30	.65
703 ASJ, 2"(51mm)	.47	.62	1.01	.87	.51	.32	.75
705 ASJ, 1"(25mm)	.20	.64	.33	.66	.84	.33	.60
705 ASJ, 2"(61mm)	.58	.49	.73	.76	.55	.35	.65

Fiberglas® Pipe And Tank Insulation

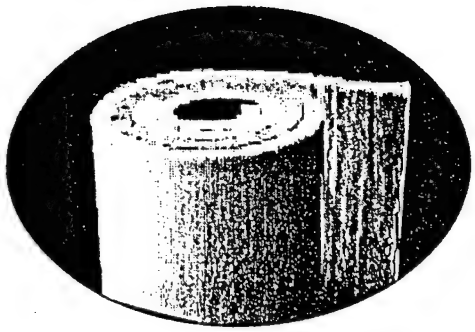
PHYSICAL PROPERTY DATA

Property	Test Method	Specifications
Operating temperature range*	ASTM C 411	0 to 650°F* (-18°C to 343°C)
Insulation jacket temperature limitation	ASTM C 1136	-20°F to 150°F (-29°C to 66°C)
Jacket permeance	ASTM E 96, Proc. A	0.02 perm
Puncture resistance	ASTM D 781	50 units
Compressive strength at 10% deformation	ASTM C 165	125 lb/ft² (5985 Pa) minimum
Surface burning characteristics	ASTM E 84**	Flame spread,25; Smoke developed,50

*Maximum thickness at 650°F (343°C): 8" (203mm).

Thermal Performance

Insulation Thickness	Operating Temperature											
	200°F (93°C)		300°F (148°C)		400°F (204°C)		500°F (260°C)		600°F (316°C)	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
1" (25mm)	32	101	67	110	111	140	167	184	236	191
1½" (38mm)	23	95	47	100	78	125	116	142	164	163
2" (51mm)	17	92	36	103	60	118	89	130	125	147
2½" (64mm)	14	90	29	89	48	110	73	122	102	136
3" (76mm)	12	88	25	96	41	106	61	117	86	128
3½" (89mm)	10	87	21	94	36	102	52	112	74	123
4" (102mm)	9	87	19	93	31	100	46	108	65	118



DESCRIPTION

Fiberglas Pipe and Tank Insulation is made of semirigid fibrous glass board material,factory-jacketed with a laminated kraft-aluminum foil ASJ facing. The insulation is adhered with the end grain perpendicular to the jacket. This provides a flexible product that is easily wrapped around pipes, tanks, or vessels while providing a degree of rigidity and abuse-resistance second only to hard insulations like calcium silicate.

AVAILABILITY

Thickness	Recommended Pipe Size	Roll Length
1" (25mm)	10" (250mm) & up	42 ft.(12.8m)
1¼" (38mm)	10" (250mm) & up	27 ft. (8.2m)
2" (51mm)	10" (250mm) & up	20 ft.(6.1m)
2¼" (64mm)	14" (350mm) & up	26 ft. (7.9m)
3" (76mm)	17" (425mm) & up	21 ft. (6.4m)
3¼" (89mm)	20" (500mm) & up	18 ft. (5.5m)
4" (102mm)	23" (575mm) & up	16 ft.(4.9m)

Fiberglas® Insul-Quick® Insulation

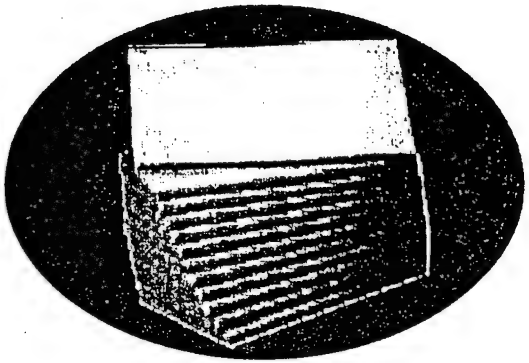
PHYSICAL PROPERTY DATA

Property	Test Method	Specifications
Hot surface performance	ASTM C 411	Up to 850°F (454°C), maximum thickness of 6" (152mm) Up to 650°F (343°C), maximum thickness of 8" (203mm)
Compressive strength at 10% deformation at 25% deformation	ASTM C 165	 125 lb/ft² (5985 Pa) 90 lb/ft² (4309 Pa)
Nominal density	ASTM C 167	3.0 pcf (48 kg/m³)
Water vapor sorption	ASTM C 1104	≤ 2.0% by weight at 120°F (49°C), 95% R.H.
Shot content	ASTM C 612	Negligible
Surface burning characteristics	ASTM E 84*	Flame spread, 25*; Smoke developed, 50

Thermal Performance

Insulation Thickness, inches (mm)	Operating Temperature									
	450°F (232°C)		550°F (288°C)		650°F (343°C)		750°F (399°C)		850°F (454°C)	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
1" (25mm)	108	181	159	216	222	257	303	304	404	357
2" (51mm)	60	142	87	164	122	191	166	221	221	256
3" (76mm)	41	126	60	143	84	162	114	185	153	212
4" (102mm)	31	117	46	130	64	146	87	165	116	186
5" (127mm)	25	111	37	122	52	136	70	151	94	170
6" (152mm)	21	107	31	117	44	128	59	142	79	158
7" (178mm)	18	104	27	112	38	123	51	135	68	149
8" (203mm)	16	101	24	109	33	118	45	129	60	142

The above table provides approximate heat loss values (HL), Btu/hr-ft², and surface temperatures (ST), °F, for flat surfaces. Values are based on horizontal heat flow, vertical flat surface, 80°F (27°C) ambient temperature, still air, weathered aluminum jacket. To convert heat loss values to W/m², multiply values shown by 3.15. To convert surface temperatures, use the formula: °C = (°F-32)/1.8.



- **Large size availability** – Boards in sizes to 4 feet by 8 feet (1219mm x 2438mm) help reduce the number of joints, speeding installation and eliminating potential sources of heat leakage. Other types of fibrous insulations are not as easy to handle in large-size boards. This feature improves installation cost.

DESCRIPTION

Fiberglas Insul-Quick insulation is a lightweight insulation composed of glass fibers bonded together in a semi-rigid, boardlike form with a special high-temperature binder.

Fiberglas® TIW Types I And II Insulation

PHYSICAL PROPERTY DATA

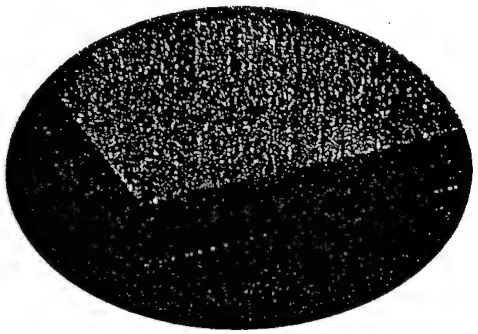
Property	Test Method	Specifications
Equipment operating temperature range*	ASTM C 411	Up to 1000°F (538°C)
Nominal density	ASTM C 167	Type I: 1.0 pcf (16 kg/m³) Type II:2.4 pcf (38 kg/m³)
Shot content	ASTM C 612	Negligible
Water vapor sorption	ASTM C 1104	<2.0% by weight at 120°F (49°C),95% R.H.
Surface burning characteristics	ASTM E 84**	Flame spread,25**; Smoke developed,50

*Maximum allowable thickness at 1000°F (538°C) – Type I: 8.5" (216mm); Type II: 6" (152mm).

Thermal Performance

Insulation Thickness	Operating Temperature, °F (°C)							
	400°F (204°C)		600°F (326°C)		800°F (427°C)		1000°F (538°C)	
TIW Type I	HL	ST	HL	ST	HL	ST	HL	ST
1" (25mm)	118	188	283	292	583	441	1114	634
2" (51mm)	66	148	160	217	335	321	659	472
3" (76mm)	46	130	111	183	234	264	463	386
4" (102mm)	35	121	85	163	179	230	356	333
5" (127mm)	29	114	69	150	145	207	289	296
6" (152mm)	24	110	58	141	122	191	243	270
7" (178mm)	21	106	50	134	105	178	210	249
8" (204mm)	18	104	44	129	93	169	185	233
TIW Type II								
1" (25mm)	93	169	211	250	416	363	761	513
2" (51mm)	51	135	116	186	230	261	425	368
3" (76mm)	35	121	80	159	158	216	294	299
4" (102mm)	27	113	61	144	121	190	224	258
5" (127mm)	22	107	49	133	98	173	181	231
6" (152mm)	18	104	42	126	82	160	152	212

The above table provides approximate heat loss values (HL), Btu/hr-ft², and surface temperatures (ST), °F, for flat surfaces. Values are based on horizontal heat flow, vertical flat surface, 80°F (27°C) ambient temperature, still air, weathered aluminum jacket. To convert heat loss values to W/m², multiply values shown by 3.15. To convert surface temperatures, use the formula: °C = (°F-32)/1.8.



DESCRIPTION

Fiberglas TIW Types I and II are made of off-white to light tan,noncombustible wool with long,resilient,inorganic glass fibers bonded with a thermosetting resin.TIW Type I is available in rolls while TIW Type II comes in batts only.

AVAILABILITY

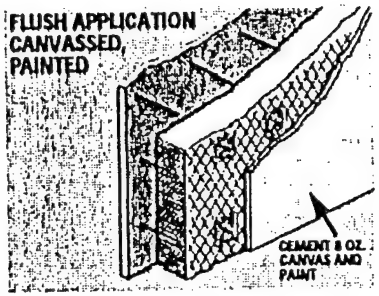
TIW, Type I
Standard roll sizes:

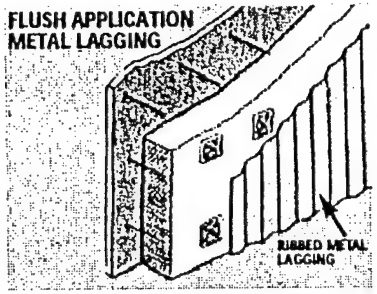
Widths:	24" (610mm)	48" (1219mm)	
Lengths:	76' (19.3m)	52' (13.2m)	38' (9.6m)
Thicknesses:	1" (25mm)	2" (51mm)	3" (76mm)
	4" (102mm)		

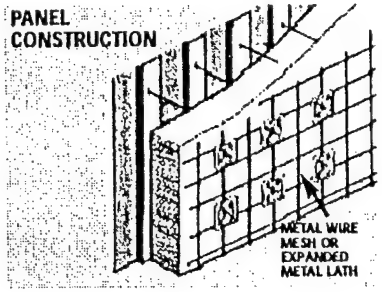
TIW, Type II
Standard batts: 2'x4' (610mm x 1219mm); 3'x4' (914mm x 1219mm); 4'x4' (1219mm x 1219mm); 4'x8' (1219mm x 2438mm)
Thicknesses: 1" (25mm) to 4" (102mm) in ½" (13mm) increments

Design Considerations

Installation Recommendations for Insul-Quick Insulation and Fiberglas TIW Types I and II Insulation Products







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Insulation Thickness Computer Program

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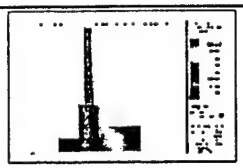

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US Department of Energy

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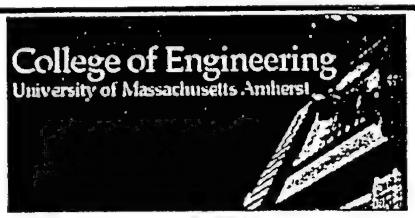

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CHAPTER IV
STANDARD HEAT FLOW CALCULATIONS

This is the third option on the main 3EPLUS21 menu. The program will start by displaying a menu to allow the user to select from one of four calculation types. The default is the screen setup for the Maximum Surface Temperature Using 1 Insulation Material.

HELP

To get HELP on any question, press the F1 function key. A message box will display more information about the question. As you move the cursor around the screen, you can press F1 to get help on the input variable where the cursor is located. The user can request HELP at any time in the program. In some cases, typical values will be suggested. After reading the HELP screen, press ENTER to return to the original point of departure.

MAIN MENU

To display the main menu, press the F2 function key. A pulldown menu will appear. Use the left and right arrow keys to change menus. There are three topics on the top row of the menus, they are:

DO WHAT REPORT SURFACE TYPE

DO WHAT

The program will do four different types of calculations. The four types are:

Maximum Surface Temperature Using 1 Insulation Material
Maximum Surface Temperature Using 2 Insulation Materials
Standard Heat Loss or Gain Calculations
Heat Loss or Gain Tables

Each type of calculation is explained briefly below. To choose a calculation type, use the Up or Down arrow key to move the selection bar, then press the ENTER key.

REPORT

When requested, the program will print a report on the printer unless the user changes the report location to a disk file. To select a disk file, use the Up or Down arrow keys to select Disk, then press the ENTER key. The program output will be written to a disk file that can

be imported into a word processor. This allows the user to include the report in a proposal, bid, or other document.

SURFACE TYPE

The program will allow one of 5 surface types. The five types are:

Horizontal piping or tanks
Vertical piping or tanks
Vertical flat surface
Top or bottom of tank or duct

The program assumes a horizontal pipe unless the user changes to another surface type. To choose a surface type, use the Up or Down arrow keys to move the selection bar, then press the ENTER key.

CALCULATION TYPES

This is a brief description of each of the 4 calculation types.

THICKNESS FOR MAXIMUM SURFACE TEMPERATURE OR THICKNESS FOR CONDENSATION CONTROL USING 1 INSULATION MATERIAL

Use this calculation type to determine the amount of insulation to use for personnel protection or any other specification requiring a maximum surface temperature or a condensation control thickness. The program will display a screen of questions. Answer any or all the questions depending on the applications. The program will display a table of insulation thicknesses from ½ inch to 10 inch and allow the user to quickly determine the amount of insulation required.

To change any value displayed on the screen, move the cursor to the question using the Up or Down arrow keys, then type a new value. You can use the arrow keys to move the cursor to any question on the screen. You may also press the ENTER key without typing any new information and the cursor will go to the next question without changing the information.

The first question is the process temperature. This may be above ambient for a hot surface or below ambient for a cold surface. The screen will change if you type a cold surface temperature. Type the process temperature in degrees Fahrenheit(°F). This should be an average temperature for normal calculations. To determine the heat loss and surface temperature for an abnormal situation, type an extreme temperature that represents the lowest or highest possible temperature the process could encounter.

Next type the ambient temperature. This should be the average ambient temperature for normal calculations. To see the possible variation from night to day or from month to month, type different ambient temperatures representing the extreme conditions the process could be exposed to. Good sources of average temperatures are the US Weather Service or a local Chamber of Commerce. If the piping or equipment is indoors, then type an average temperature representing the indoor conditions. In some situations, such as underground piping, the ambient may be considerably different than expected. Changing the ambient temperature has a large effect on the calculated surface temperature and a smaller effect on the heat loss or gain.

Next type the emittance of the bare surface. This will be used to calculate the heat loss or gain of the uninsulated surface. This heat flow can be used as the basis for efficiency calculations. The default emittance represents a weathered steel surface. Press the HELP key to display other possible values. This number has a very large effect on the calculated heat losses and on the insulation efficiency calculation.

Type the surface emittance of the insulation outer surface. This value is very important and has a large effect on the calculated surface temperature. The default value of 0.1 represents Aluminum jacketing that has some oxidation and has been exposed to the weather for a few years. The type of outer jacketing should be carefully chosen depending on the application. For hot surface application, chose a material that has a higher emittance to reduce the surface temperature. This is illustrated in Examples 5 and 6.

If the operating temperature is above the ambient, then the next question is for the maximum allowable surface temperature. At the time this manual was written, no actual government or consensus standard existed for a personnel protection standard. The number 140°F is the most popular temperature used by manufacturing companies. The maximum surface temperature for personnel protection is largely dependent on the type of surface, such as metal or painted cloth. Type a new temperature or use the existing temperature by press an arrow key or pressing the ENTER key.

If the operating temperature is below the ambient, the next question displayed is the relative humidity. This number is used to calculate the dew point temperature and will be used to calculate the condensation control thickness. Type a relative humidity that best represents the average for the summer months. To estimate the worst case situation, type a number that represents the extreme humidity the insulation will be exposed to. The relative humidity the insulation is exposed to may not necessarily be the relative humidity furnished by the weather service. If the equipment is below ground, the humidity may be different than expected, especially if the equipment is enclosed in an unheated space. The design relative humidity should be given some attention to prevent future insulation problems.

The last question is for the insulation material. To change the insulation material, locate the cursor on the insulation material displayed on the screen and press the ENTER key. A list of insulation materials will be displayed. Select a new material by using the Up or Down arrow keys to move the selection bar then pressing ENTER. If you have many insulation materials stored in the program, you will need to use the Page Up or Page Down keys to display more materials.

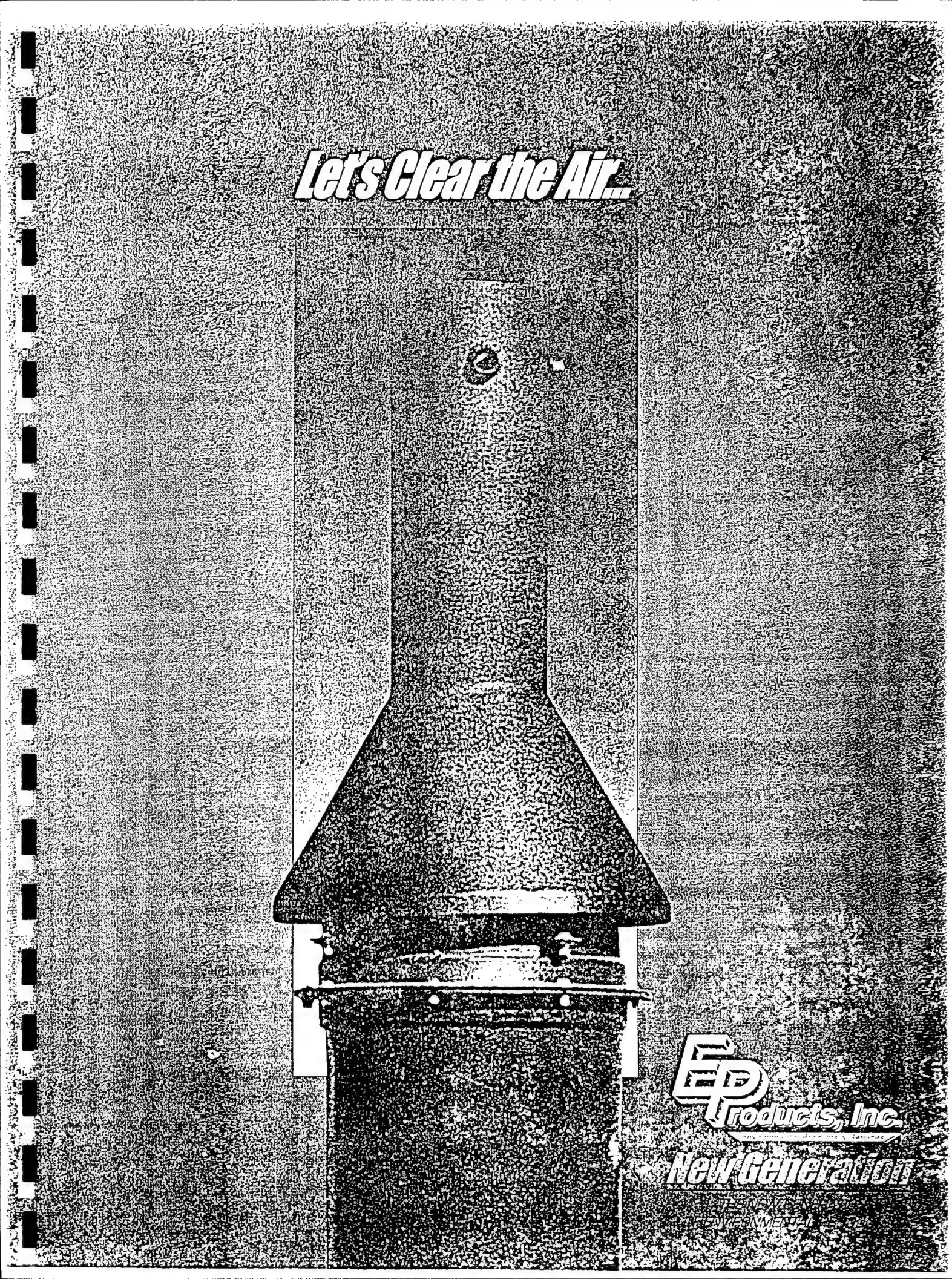
The cursor will return to the top question. If you are satisfied with the information you have typed into the program and are ready to display the results, press the F3 function key to start the calculations. The screen will change to display the information you typed into the program and a table of heat flows and surface temperatures at different insulation thicknesses.

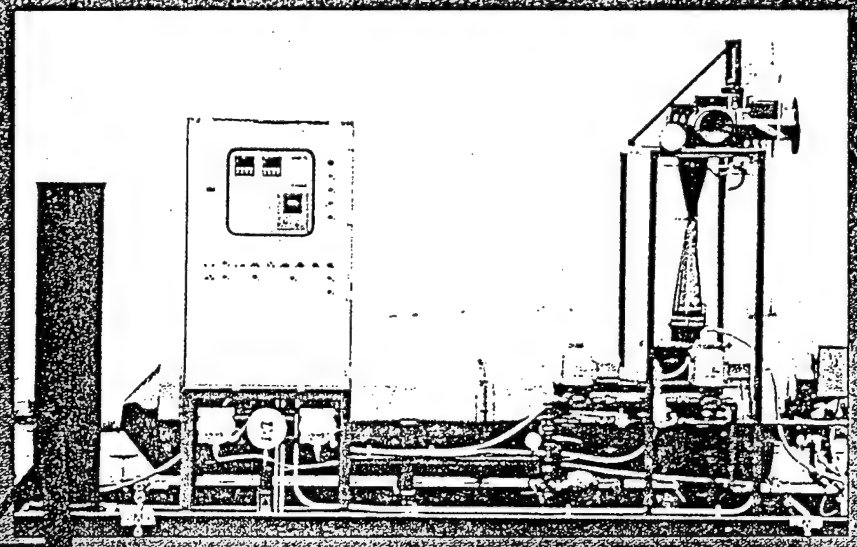
If the operating surface temperature was hotter than the ambient, then the display will also show the thickness required to meet the maximum surface temperature you typed. If the operating temperature was below the ambient, then the display will show the thickness of insulation required to keep the insulation surface temperature above the condensation temperature.

If your printer is ready, a message will appear at the bottom of the screen allowing you to make a printed report. To print the report, press the F3 key again. If the printer is not ready, then the message will tell the user to press any key to continue.

SECTION 3

THERMAL OXIDIZERS


Let's Clear the Air...
EP Products, Inc.
New Generation



Low BTU Thermal Oxidizer

At E Products, Inc., thermal oxidation is a custom art in addition to being an engineering science. Our unique design has proved to be the most effective method of destroying hazardous hydrocarbon waste and controlling hydrocarbon emissions. Our design is also the most economical in terms of total cost — including the initial investment, maintenance and operating costs.

To better serve our customers, E Products professionals evaluate your total emission control needs — including influent, effluent, process loading, and sequencing. Examining all of these factors individually and collectively helps us ensure delivery of a properly sized and designed system. Because of the experience and diversity of our engineering staff, we at E Products help our customers handle high BTU fume streams and save money by reducing fuel costs and lowering maintenance requirements.

Our mission is simple: design and manufacture reliable, cost-effective equipment that provides our customers with a final solution while benefiting the environment. We look forward to working with you to create the perfect solution for your operation.

Industrial Remediation

Here at E Products, our people have been in the business for generations. That's the kind of experience and expertise that enables us to create custom solutions for our customers.

The combustion engineering industry divides thermal oxidizers into two basic groups of systems: (1) low BTU systems that operate with fumes that have a concentration of less than 25% of the lower explosive limit (L.E.L.), and (2) high BTU systems that operate with fumes of 25% L.E.L. and greater.

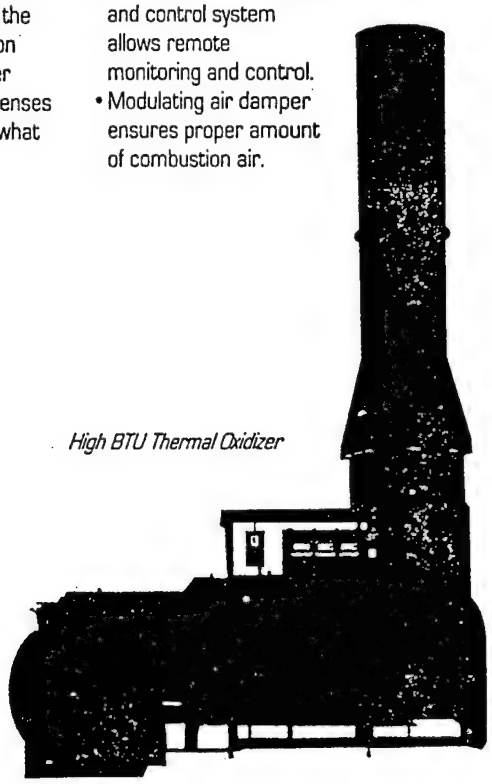
Although high BTU fumes can be diluted, such a system normally becomes too expensive to operate because of excessive fuel costs. Diluting the fume stream also requires expensive analyzers and costly calibration procedures.

Now, E Products has created a more efficient, cost-effective alternative — a new generation of high BTU thermal oxidizers. Our high BTU systems have the natural advantage of higher destruction efficiencies, lower fuel bills, and smaller equipment size. Best of all, capital expenses and operating costs are a fraction of what you'd expect.

E Products, Inc. Thermal Oxidizer Design and Equipment Advantages

More and more facilities are choosing thermal oxidizers from E Products, Inc. ... and with good reason:

- Ceramic, venturi-shaped burner tile eliminates possibility of flashback.
- Controlled by temperature, not L.E.L. eliminating the need for an L.E.L. analyzer.
- Combustion air fan stat control; wide turn-down range for efficient temperature control.
- Handles concentrations above, below and through the L.E.L.
- Monolithically cast refractory ignition tube for flame front stability.
- NO_x emissions of less than 50 ppm.
- CO emissions of less than 100 ppm.
- Sight ports for visual inspection of flame.
- Optional remote telemetry and control system allows remote monitoring and control.
- Modulating air damper ensures proper amount of combustion air.



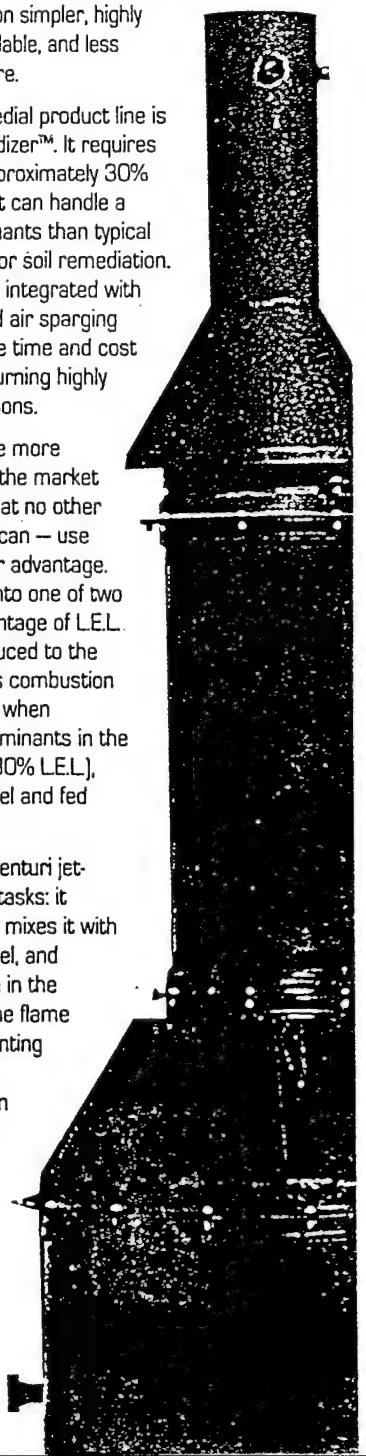
High BTU Thermal Oxidizer

The E Products engineering staff combines years of experience with advanced technology to create the most effective remediation products on the market today.
Every E Products design is rooted in the same philosophy — create transportable, reusable systems that make regulatory compliance and environmental remediation simpler, highly automated, more dependable, and less expensive than ever before.

The flagship of our remedial product line is the Venturi Thermal Oxidizer™. It requires no L.E.L. monitor, it's approximately 30% more fuel efficient, and it can handle a wider range of contaminants than typical thermal oxidizers used for soil remediation. The oxidizers are readily integrated with soil vapor extraction and air sparging systems to decrease the time and cost of site remediation by burning highly concentrated hydrocarbons.

E Products' oxidizers are more efficient than others on the market because they can do what no other thermal oxidizer design can — use the fume stream to your advantage. Fumes are introduced into one of two points. When the percentage of L.E.L. is low, fumes are introduced to the combustion chamber as combustion air rather than fuel. But when concentrations of contaminants in the fumes are high (above 30% L.E.L.), fumes are treated as fuel and fed directly to the burner.

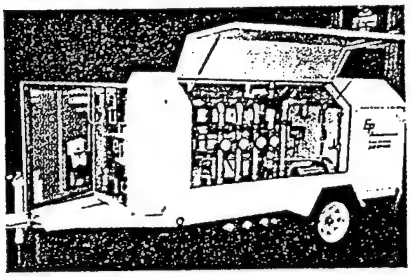
Our specially designed venturi jet-burner performs three tasks: it induces combustion air, mixes it with the fume stream and fuel, and accelerates the mixture in the venturi throat beyond the flame propagation rate, preventing flashback. The result is contaminant destruction rates of up to 99.99% with CO_2 and water vapor being released into the atmosphere through the stack.



Ground Flares

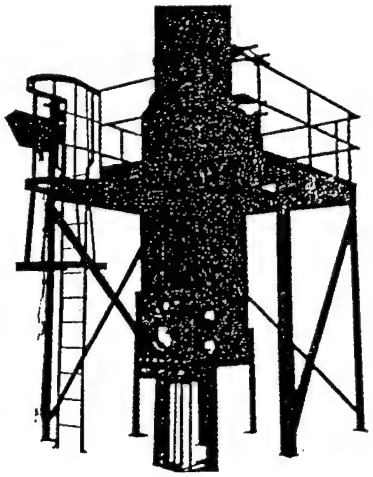
Advantages of E Products Thermal Oxidation for Soil Remediation

- Provides a final solution.
- Allows economical heat recovery.



Air Sparging/SVE Remedial System for Use with Remedial Thermal Oxidizer

- Accomodates rich hydrocarbon fumes safely — can be self-incinerating, reducing fuel requirement to practically zero.
- Allows fumes containing 16% or more O_2 to be used as the source of combustion air, saving up to 30% of fuel requirements.
- Requires minimum maintenance because there is no fouling or further disposal problems.



Enclosed Ground Flare

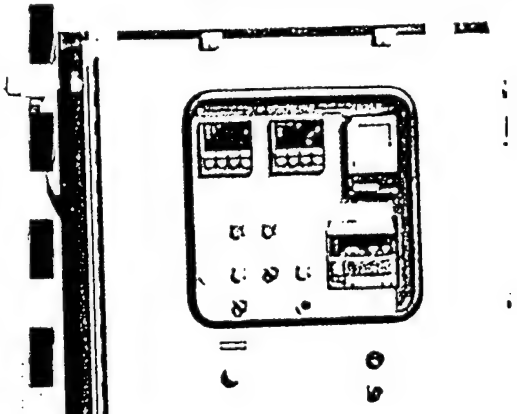
While the concept of flare design is simple, implementation requires a great deal of knowledge and experience. E Products professionals are well equipped to help you plan, design and implement the ground flare system that is perfect for your operation.

E Products ground flares safely and effectively control methane gas created by solid waste decomposition. As a bonus, heat recovered from the flare can be turned into an energy source by using a heat exchanger or generator.

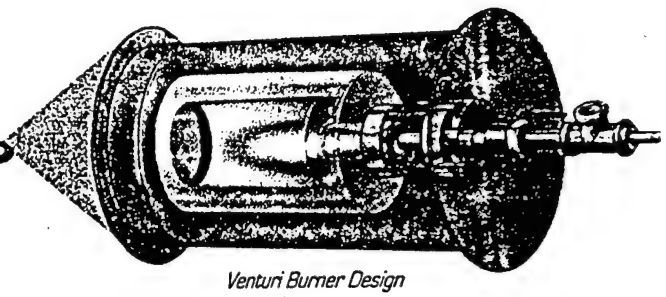
Benefits of ground flares include a safe operating environment, high destruction rates, low emissions, high turn-down ratios, and durability. High destruction rates and low emissions are the direct results of efficient burning — a hallmark of the E Products burner design.

Many of our ground flare solutions revolve around the burner design. Our ground flares offer many significant advantages, making them the best solution for most applications:

- High destruction rates.
- Low NO_x.
- Low CO emissions.
- Safety controls.
- Wide range of fume BTU loading.



Remediation Thermal Oxidizer



Venturi Burner Design

And Soil and Water

E Products, Inc. is proud to bring you a new generation of technologically advanced products designed to increase efficiency and reliability as well as help you drive down the costs of cleaning the air, soil and water.

We didn't invent the thermal oxidizer, but we did perfect it. That's why so many consulting engineers and industrial companies have turned to us for smart solutions to their toughest environmental problems.

Reliability

We know you're looking for solutions that work. But that's not enough. You're looking for products you can count on to work over the long haul, products you can trust to stay on the job with a minimum of maintenance and downtime. That's exactly what you get with E Products oxidizers. Our Venturi Thermal Oxidizer™ and all of our other products are built to last ... and provide trouble-free service year after year.

"In Our Experience, E Products Provides the Safest, Most Reliable Thermal Oxidizer Available"
Environmental Consultant – Middletown, PA

Safety

E Products thermal oxidizers and enclosed ground flares are among the safest on the market. Our unique design leaves less margin for error than ever before making their operation inherently safe.

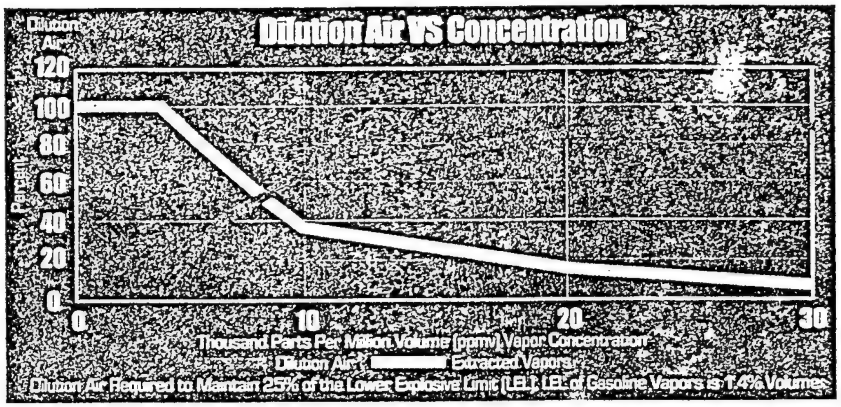
Cost

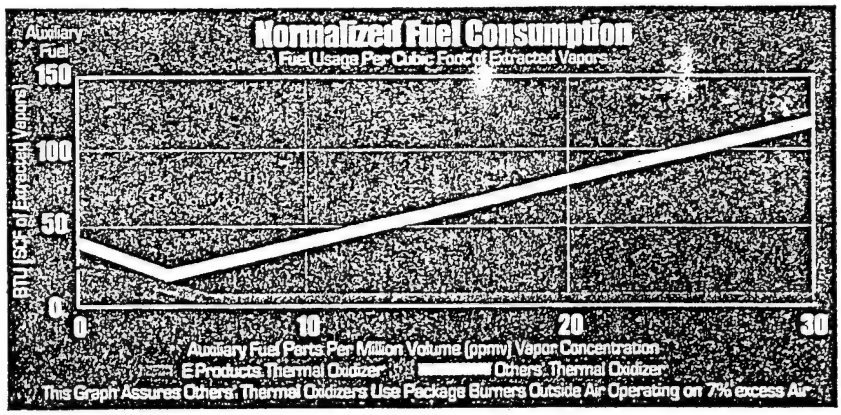
Products and systems from E Products offer many benefits that add up to significant cost savings. For instance, our high BTU thermal oxidizers have the natural advantage of higher destruction efficiencies, lower fuel bills, and incredibly low capital and operating costs.

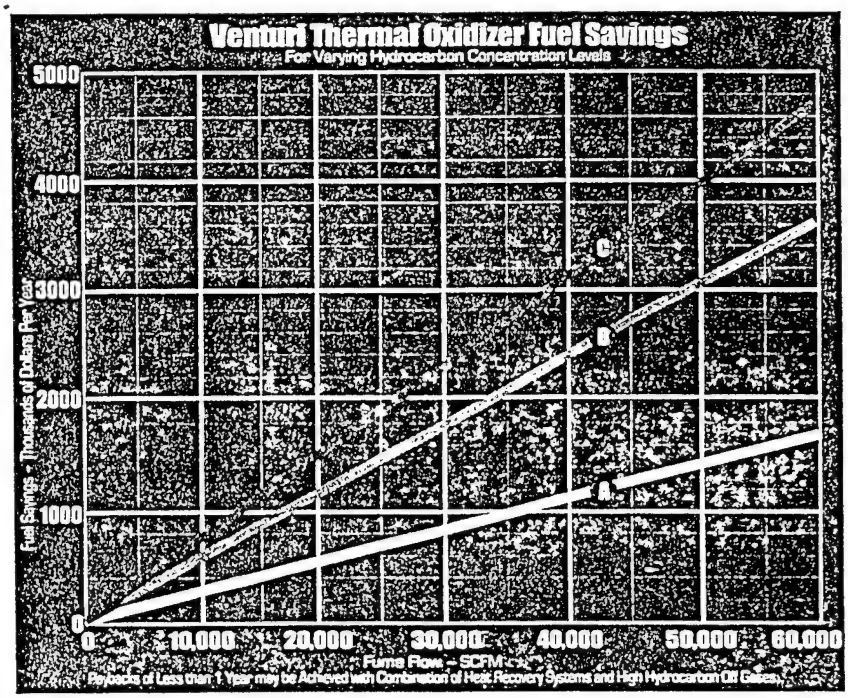
"E Products Provides the Most Cost-effective Oxidation System from a Total Cost Analysis. As Distributors, This Makes Our Job Much Easier"
Equipment Distributor – Houston, TX

Flexibility

Thermal oxidizers from E Products can be used for a wide variety of applications and varying temperature ranges, so the products you buy today will still be on the job well into the future. We also offer flexibility in financing. With a variety of lease, rental and purchase options available, our products are a smart and affordable investment that will pay dividends over the years.





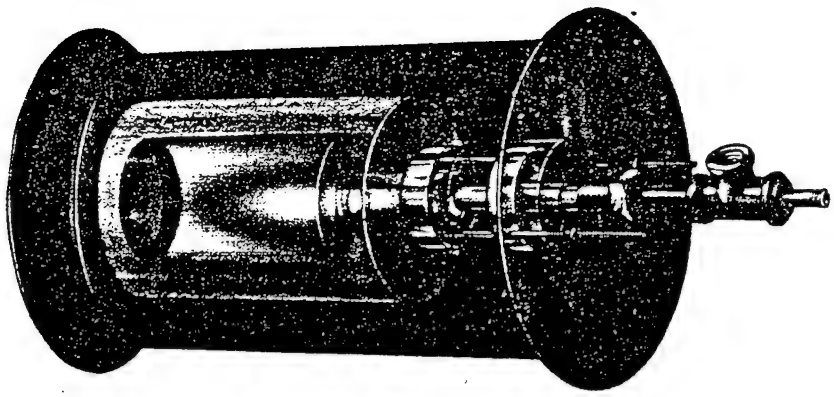


A Utilizing full benefit of oxygen in fume stream, as opposed to supplying fresh air for burner

B As A plus credit given for concentrating hydrocarbon in fume stream to 25% L.E.L.

C As B but concentrating hydrocarbons to 40% L.E.L.

L.E.L. Lower explosive limit of hydrocarbons in fuel stream BASIS: • Fume Inlet – 70F • Incineration Temperature – 1400F • Operating Hours – 8,000/Year • Projected Fuel Cost – $5.00/MM BTU



Let E Products help you clear the air, soil and water ...
and help you keep costs in line.
Write, phone or fax today for more information.

E Products, Inc.
Environmental Products & Services

New Generation

THE NEW GENERATION
OF ENVIRONMENTAL PRODUCTS

E Products, Inc.

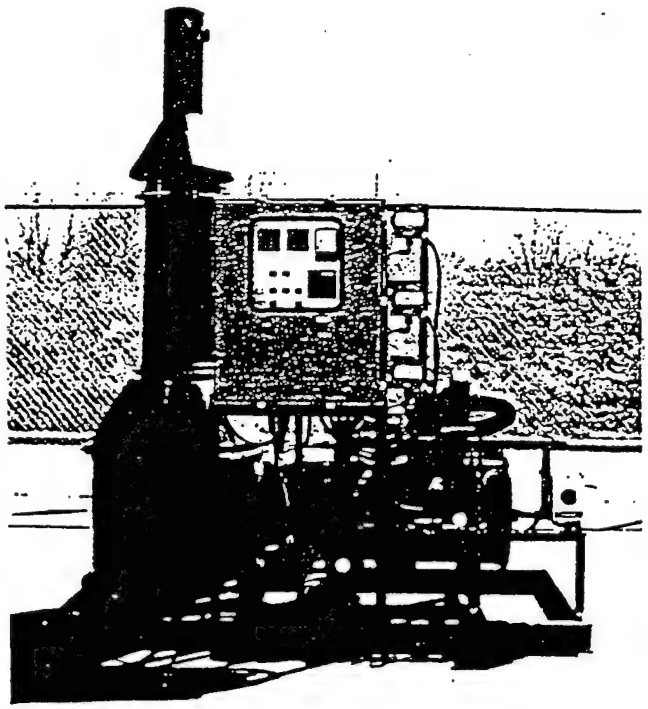
Environmental Remediation Products & Services

Venturi Thermal Oxidizer™

HERE'S HOW IT WORKS

The new generation of Venturi Thermal Oxidizers,™ manufactured by E Products, Inc., St. Paul, Minnesota, increase oxidation rates of a wider range of contaminants while cutting fuel costs by approximately 30%. These portable units can be integrated with soil vapor extraction and air sparging systems to decrease the time and cost of site remediation by burning highly concentrated hydrocarbons.

The hydrocarbon fume stream is introduced to the thermal oxidizer at one of two different points. In the first scenario, when fume contaminant concentrations are high, or above 30% of the lower explosive limit (LEL), fumes are treated as fuel and introduced directly to the burner. The unique venturi jet-burner then performs three tasks: it induces combustion air, mixes it with the fume stream and fuel, and accelerates the mixture in the venturi throat beyond the flame propagation velocity, preventing the flame from flashing back. The flow of combustion air and auxiliary fuel is controlled, allowing the combustion chamber to maintain a constant temperature. When the fume stream can no longer sustain combustion on its own, auxiliary fuel is increased.



When the percentage of LEL is low, it is more efficient to introduce the fume stream as combustion air rather than fuel. In this case, a portion of the fume stream passes around the burner, serving as combustion air. Because of their temperature difference, the remainder of the fume stream mixes rapidly with the hot gasses from the burner. This allows the mixture to use the entire combustion chamber length for thermal oxidation. The result is contaminant destruction rates of up to 99.99% with CO_2 and water vapor being released into the atmosphere through the stack.

For more information regarding thermal oxidizers for remedial or industrial applications, please contact Stephen Hirt, director of sales, at (612)490-3798

STANDARD SPECIFICATION
REMEDIATION THERMAL OXIDIZER

This is a specification for a horizontal forced draft fume thermal oxidizer for destroying hydrocarbon vapors. The standard unit will consist of a burner system, temperature control system, combustion safeguard system, forced draft combustion air fan, and a stack.

SPECIFICATIONS

A. 1400°F operating temperature with 0.5 second residence time.
B. Destruction rates in excess of 99%
C. Auxiliary burner turndown range of 4:1.
D. Vapor concentration may vary from 0% LEL through and above the explosive range (above 100% LEL).
E. Carbon steel construction with internal insulation.
F. Factory Mutual style pipe train for natural gas or LPG which branches to provide fuel to the pilot as well as the burner.
G. Factory Mutual style pipe train for hydrocarbon vapor allowing introduction into either of two connections on the oxidizer.
H. The unit is pre-piped, wired and tested before shipping.

OPERATIONAL MECHANICS

A. BURNER SYSTEM

1. The fumes enter a distribution plenum. The air carrying the fumes is used as the oxygen supply for the combustion process, eliminating the need for outside combustion air. (This results in a fuel saving up to 30%.) A coaxial nozzle mix burner is used to supply the combustion gases. The nozzle-mix type burner eliminates the possibility of flashing back to a remote mixing device. It can be turned down, without hazard, until the fire is extinguished, then readily re-ignited from the pilot. The burner produces a large cross-sectional area flame pattern for easy mixing with the fumes, which minimizes fume bypass.

4590 Mevielleemy Street • St. Paul, Minnesota 55127-6004 • Phone (612) 490-9690 • Fax (612) 490-9840 • E-Mail epi@minn.net

2. The combustion chamber is insulated with a low specific heat, lightweight, insulating, castable refractory which is molded to an engineered contour for the most intimate mixing of the combustion gases and the cold fumes. The fuel gas/air/fume mixing results in minimum operating temperature for economical fuel requirements. The refractory is encased in a cylindrical steel shell for maximum strength. The shell is structurally supported, with its centerline matching the blower centerline.

B. TEMPERATURE CONTROL SYSTEM

1. In order to conserve fuel, the temperature of the thermal oxidizer gas discharge is carefully controlled to the programmed minimum destruction temperature.
2. An electronic PID controller, with thermocouple burn-out safeguard, actuates a gas control valve and blower damper to hold the operating temperature at the set point.

C. COMBUSTION SAFEGUARD SYSTEM

1. In order to assure that the burner is operating normally and the start-up sequence has been properly followed, a combustion safeguard relay using an ultraviolet sensor is supplied. The combustion safeguard relay is interlocked to the blower starter, draft switch, high temperature limit, high and low gas pressure switches and alarm.
2. A Factory Mutual approved main gas safety shut-off valve and pilot solenoid is installed in the gas lines so that in case of flame failure, the pilot and main gas will be automatically shut off, the alarm sounded, and the component failure indicated by extinguishing of an operating light.
3. A NEMA 4 enclosure with an instrument window is supplied containing control transformer for converting supply power to control power, operating lights to show normal operation, combustion safeguard system, blower starter, alarm with silencing switch, temperature recorder, terminal strips, control circuit fuse, and nameplates.

D. FORCED DRAFT COMBUSTION FAN

1. A force draft fan having a 150°F impeller is furnished. The forced draft arrangement assures that the fan operates on cool gases to reduce fan maintenance.

E. STACK

1. The thermal oxidizer discharges into a stack which extends 10' above equipment grade. Dilution air is induced into the stack base, reducing discharge temperatures to 700°F.

OPTIONAL EQUIPMENT AND SERVICES

A. Trailer mounted thermal oxidizer system.

B. Extended combustion chamber to increase residence time to achieve higher destruction efficiencies.

C. Heat exchanger to preheat fumes and reduce fuel consumption.

D. Catalytic oxidizer modules allowing oxidation to be achieved at lower temperatures, thus reducing fuel consumption.

E. Flame arrestor as an added protection against flame flashback to vapor source.

F. Vapor extraction blower system.

G. Condensate separator to collect condensables and protect the vapor extraction blower, with automatic or manual drains.

H. Autodialers or telemetry systems for daily data reports and emergency shutdown reporting.

I. Training on the operation of the thermal oxidizer.

J. Installation and start-up supervision.

Note: Custom designs such as special controls, physical arrangements, etc., can be provided upon request.

ASSEMBLY AND TESTING

A. The unit is completely assembled in our plant, and test-fired as far as practical. It is then finished with a heavy coat of high temperature synthetic enamel, and knocked down as little as possible for shipment. It is shipped to the site for installation to be completed by others.

B. All equipment manufactured will adhere to the standards set forth in the quality control program manual.

AIR POLLUTION GUARANTEE

A. We guarantee the destruction of all hydrocarbon materials to comply with the requirements of the local air pollution control authority as of the date of our proposal.

B. Site special evaluation of destruction rate and emission requirements will be made and a written guarantee will be supplied based upon the evaluation.

OPERATING ECONOMY

OPERATING MODE

A. To achieve high operating efficiency and as a result achieve low operating cost, the thermal oxidizer can operate in one of two modes.

1. When the vapor extraction stream has a high concentration of hydrocarbons, (above 25% LEL), the fumes should be directed through the high BTU fume line. This path feeds the fume directly to the burner as fuel, supplementing these fumes with auxiliary fuel only as required to maintain operating temperature.

2. When the vapor extraction stream has a low concentration of hydrocarbons, (below 25% LEL), the fumes should be directed through the low BTU fume line. This path allows a portion of the fume stream to be used as the combustion air, eliminating the addition of atmospheric air. When additional atmospheric air is added, it must be heated to the operating temperature along with the vapor extraction stream. Eliminating atmospheric combustion air results in up to a 30% fuel savings.

FEATURES

B. Units are able to achieve low operating costs for the following reasons:
   1. The burner is automatically throttled back as vapor concentration increases so that the heat of combustion of the vapors reduces the gas burner requirements at all periods and conditions of operation.
   2. Temperature is controlled at the lowest permissible level with the smallest differential so that only a minimum amount of fuel is required.
   3. When the fume contains a minimum of 16% oxygen, it is used as the source of combustion air for the burner and incineration process, eliminating the need for additional heat absorbing outside combustion air.
   4. Does not require LEL or O_2 sensors for safe operation which eliminates time spent cleaning and calibrating sensor.

INSTALLATION

The equipment needs at least the following items to be supplied by E Products, Inc. or others:

A. Suitable flat, level, stable foundation.
B. Connection of all utilities to the thermal oxidizer system terminal points, including appropriate electrical power and pressure regulated natural gas or LPG (to be determined at the time of purchase).
C. Any permits, air pollution control approvals, and any other regulatory documents which may be required.
D. Installation of the thermal oxidizer system.
E. Installation engineering and start up supervision.
F. Air pollution compliance testing.

E Products, Inc.
Environmental Products & Services

ENGINEER'S SPECIFICATION
Model Venturi 200H Remediation Thermal Oxidizer

The following is a specification for an E Products, Inc. horizontal Model Venturi-200H oxidizer to destroy hydrocarbon vapors in a fume stream.

The unit shall include the following as standard features:

- Venturi Burner: Shall be equipped with a gas-electric ignition which will ignite the main burner. The pilot burner shall be supervised by an ultraviolet flame sensor which guarantees ignition. The gas burner shall be designed to optimize the mixture of fuel, combustion air and fume stream resulting in complete combustion. The burner shall be made of ceramic material and be shaped as a Venturi which will accelerate the fumes beyond the flame propagation rate. The maximum fume heating value shall be 314,400 BTUH or 15 pounds of hydrocarbons. The maximum fume flow shall be 200 SCFM with a minimum turndown range of 4:1.
- Combustion Chamber: Shall operate at a temperature of not less than 1400°F with 0.5 second residence time. The contaminated vapor shall undergo thermal oxidation completely destroying the hydrocarbons at a typical efficiency exceeding 99.99%.
- Dilution Air Exhaust Stack: The contaminate free exhaust shall be discharged through a vertical exhaust stack and combined with atmospheric air to dilute the exit temperature to 700°F.
- Piping: All piping and associated valves shall connect gas and remediation vapor to the thermal oxidizer. The piping will include high and low pressure switches, pressure gauges and a pilot gas regulator. The entire system shall be skid or trailer mounted.
- Controller: The system shall be controlled by an automatic combustion controller. The panel enclosure shall be NEMA 4 with stainless steel drip shield, inner door, and outer lockable door with window. The controller will automatically adjust the fuel input to the hydrocarbon vapor concentration to maintain incineration temperature at a preset set point. Fuel will be added in the presence of low BTU fume stream and decreased with high BTU fume stream. If the temperature control system fails, fume stream, main burner, and pilot valves will all be shut off and an alarm actuated.
- Options are available to meet specific needs which include: heat exchanger, catalyst, trailer mounted systems, complete packages with soil vapor extraction, and telemetry systems.

This system is designed to destroy hydrocarbon vapors using thermal oxidation. The hydrocarbon vapors are extracted from contaminated soil and are incinerated at a temperature of not less than 1400°F. The temperature is automatically controlled by the combustion of the contaminated fume stream augmented by an auxiliary fuel supply. No auxiliary fuel is required when the stream concentration is of sufficient BTU value. The always present pilot burner guarantees ignition. The fume and main burner valves will shut off if the temperature control system fails and an alarm condition will be indicated.

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E Products, Inc.
Environmental Products & Services

ENGINEER'S SPECIFICATION
Model Venturi 500H Remediation Thermal Oxidizer

The following is a specification for an E Products, Inc. horizontal Model Venturi-500H oxidizer to destroy hydrocarbon vapors in a fume stream.

The unit shall include the following as standard features:

- Venturi Burner: Shall be equipped with a gas-electric ignition which will ignite the main burner. The pilot burner shall be supervised by an ultraviolet flame sensor which guarantees ignition. The gas burner shall be designed to optimize the mixture of fuel, combustion air and fume stream resulting in complete combustion. The burner shall be made of ceramic material and be shaped as a Venturi which will accelerate the fumes beyond the flame propagation rate. The maximum fume heating value shall be 750,000 BTUH or 36 pounds of hydrocarbons. The maximum fume flow shall be 500 SCFM with a minimum turndown range of 4:1.
- Combustion Chamber: Shall operate at a temperature of not less than 1400°F with 0.5 second residence time. The contaminated vapor shall undergo thermal oxidation completely destroying the hydrocarbons at a typical efficiency exceeding 99.99%.
- Dilution Air Exhaust Stack: The contaminate free exhaust shall be discharged through a vertical exhaust stack and combined with atmospheric air to dilute the exit temperature to 700°F.
- Piping: All piping and associated valves shall connect gas and remediation vapor to the thermal oxidizer. The piping will include high and low pressure switches, pressure gauges and a pilot gas regulator. The entire system shall be skid or trailer mounted.
- Controller: The system shall be controlled by an automatic combustion controller. The panel enclosure shall be NEMA 4 with stainless steel drip shield, inner door, and outer lockable door with window. The controller will automatically adjust the fuel input to the hydrocarbon vapor concentration to maintain incineration temperature at a preset set point. Fuel will be added in the presence of low BTU fume stream and decreased with high BTU fume stream. If the temperature control system fails, fume stream, main burner, and pilot valves will all be shut off and an alarm actuated.
- Options are available to meet specific needs which include: heat exchanger, catalyst, trailer mounted systems, complete packages with soil vapor extraction, and telemetry systems.

This system is designed to destroy hydrocarbon vapors using thermal oxidation. The hydrocarbon vapors are extracted from contaminated soil and are incinerated at a temperature of not less than 1400°F. The temperature is automatically controlled by the combustion of the contaminated fume stream augmented by an auxiliary fuel supply. No auxiliary fuel is required when the stream concentration is of sufficient BTU value. The always present pilot burner guarantees ignition. The fume and main burner valves will shut off if the temperature control system fails and an alarm condition will be indicated.

p:\epi\marketng\v500sp.sam

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E Products, Inc.
Environmental Products & Services

Maximum Energy Usage for E Products, Inc. Thermal Oxidizers

The table, below, shows energy usage estimates for a range of E Products, Inc. oxidizers. It is based on heating plain air to 1400°F without benefit of any fume gas (all applications will come in less than these numbers). The costs to not include catalysts or heat recovery. The numbers include efficiency improvements due to:

- Combustion air is supplied from the fume stream eliminating the need for outside combustion air which also must be heated.
- The fact that the unit is a true refractory vs. a stainless shell type, this means that the combustion chamber is much better insulated and holds the heat better.
- The burner design mixes the fuel, fume, and make up air very efficiently prior to combustion.

Model	Air Flow (SCFM)	Energy Use MMBtu/hr)	gal. hour	Propane (SCFH)	Propane[2] $/Day	Nat. Gas (SCFH)	Nat. Gas[1] ($/day)
Venturi-200H	200	.31	3.43	125.6	69.91	314	36.46
Venturi-500H	500	.79	8.57	314.0	174.78	785	91.15
Venturi-1000H	1000	1.57	17.14	628.0	349.56	1570	182.30
Venturi-1500H	1500	2.36	25.70	942.0	524.34	2355	273.45

[1] Assumes a run time of 24 hours per day and a natural gas cost of .483760/100,000 ft

[2] Assumes a run time of 24 hours per day and a propane cost of $.85/gal.

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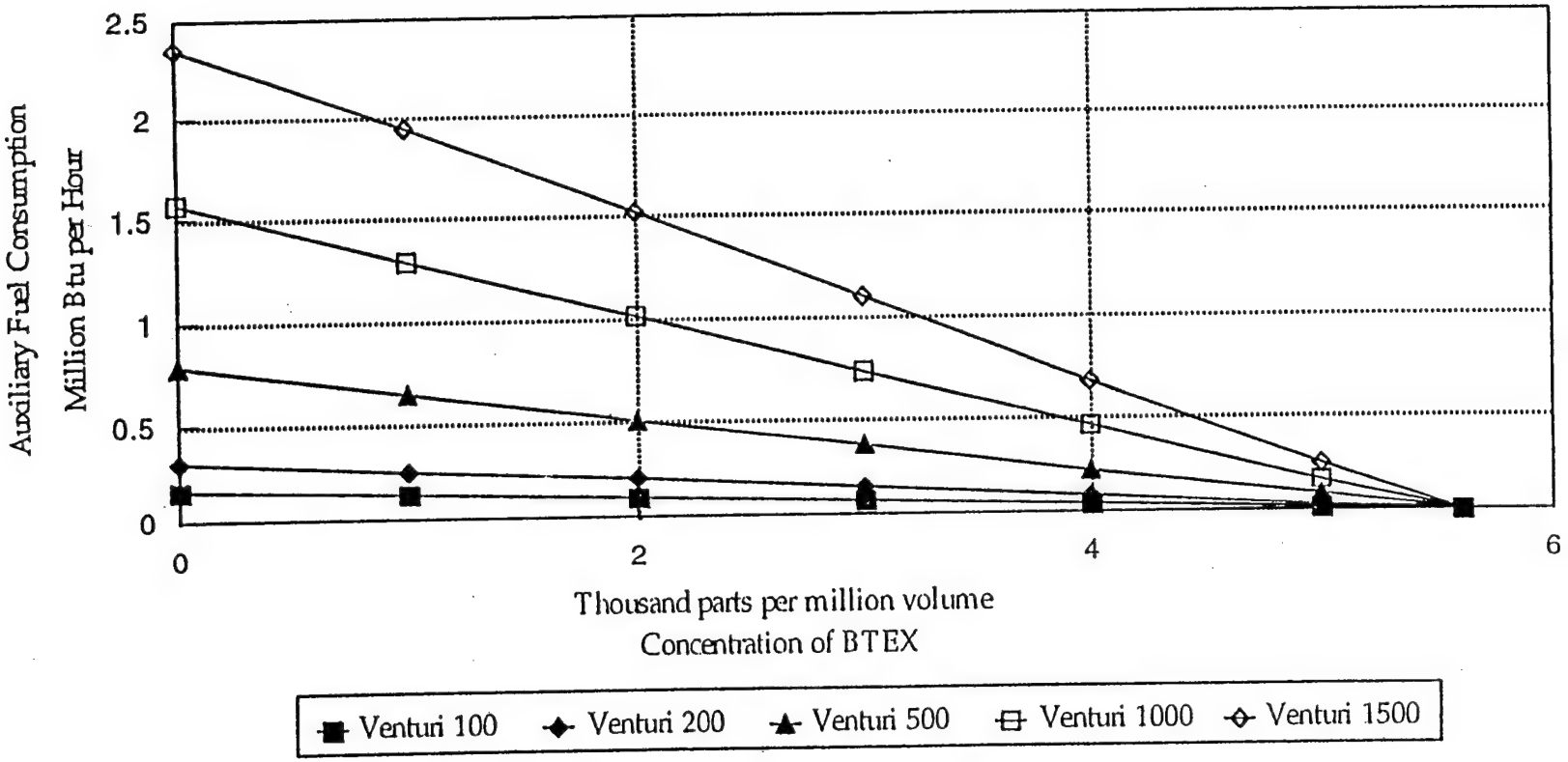
Products, Inc.
Environmental Remediation Products & Services
Minnesota • Illinois • Iowa • Wisconsin

THERMAL OXIDIZER

AUXILIARY FUEL CONSUMPTION



EP Products, Inc.
Environmental Products & Services

PARAMETERS FOR SOIL REMEDIATION THERMAL OXIDIZERS

MODEL	Venturi-200H	Venturi-500H	Venturi-1000H	Venturi-1500H
Maximum BTU Loading	300,000	750,000	1,500,000	2,250,000
Maximum Flow Capacity	200 SCFM	500 SCFM	1000 SCFM	1500 SCFM
Maximum VOC Destruction	15 LBS/HR	36 LBS/HR	73 LBS/HR	109 LB/HR
Dimensions (Given in Ft.)	10 x 4 x 8	11 x 4 x 8	13 x 5 x 8	16 x 5 x 8
Weight (Given in Pounds)	2,600	3,100	4,500	5,600
Horsepower for Blower	.5 HP	1.0 HP	1.5 HP	2.0 HP
Operating Temperature	1400°F	1400°F	1400°F	1400°F
Retention Time	.5 sec	.5 sec	.5 sec	.5 sec
Maximum Auxiliary Nat. Gas Required	314 SCFH	784 SCFH	1568 SCFH	2352 SCFH
Power Supply	230 VAC, 60 HZ, 1 PHASE OR 460 VAC, 60 HZ, 1 PHASE			

E PRODUCTS, INC.

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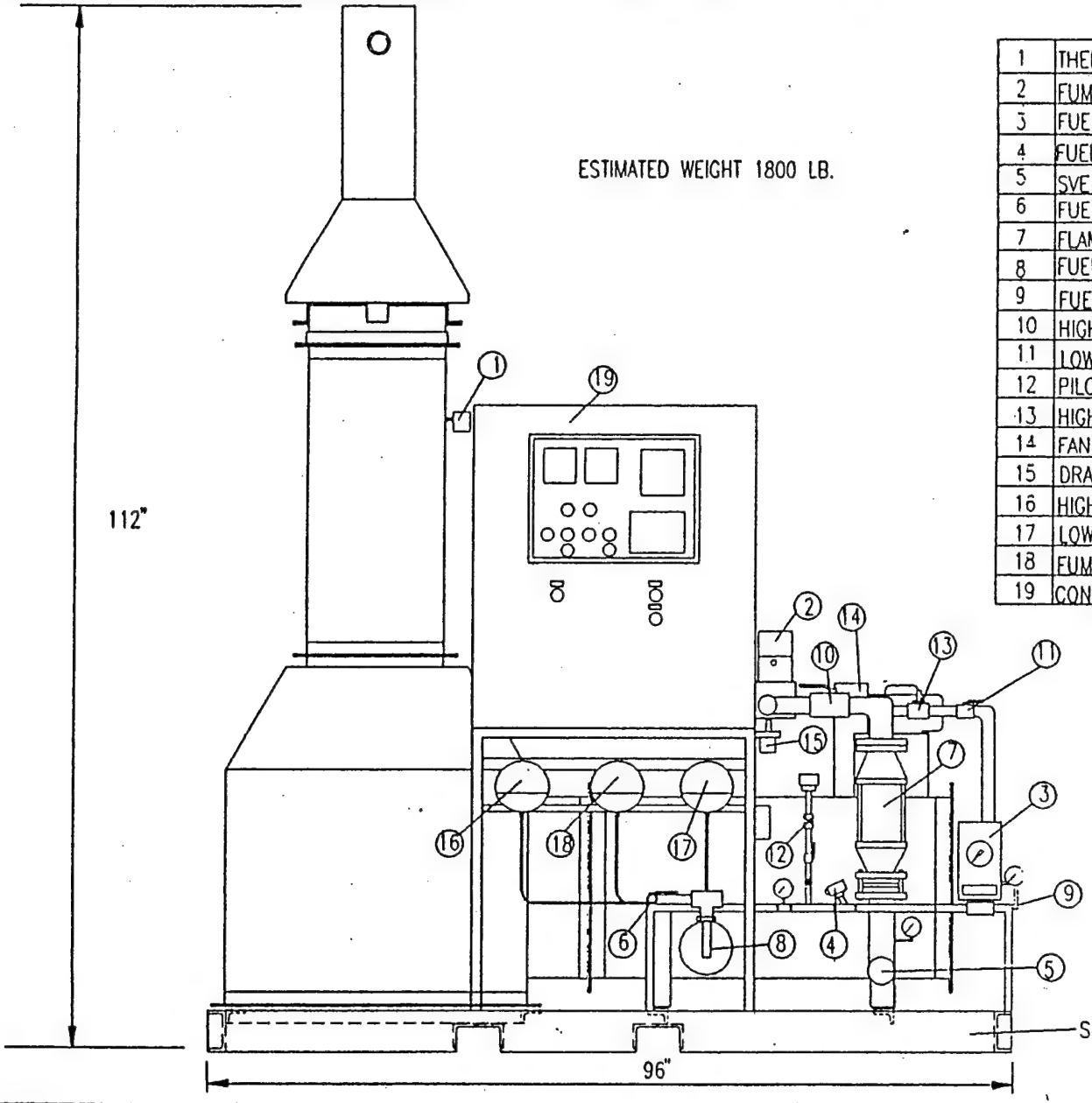

1	THERMOCOUPLE
2	FUME DRAFT MOTOR
3	FUEL CONTROL VALVE
4	FUEL SAFETY SHUTOFF VALVE
5	SVE FUME CONNECTION
6	FUEL CONNECTION
7	FLAME ARRESTER
8	FUEL REGULATOR
9	FUEL SHUTOFF VALVE
10	HIGH BTU FUME VALVE
11	LOW BTU FUME VALVE
12	PILOT NEEDLE VALVE
13	HIGH BTU LIMITING ORFICE
14	FAN
15	DRAFT SWITCH
16	HIGH FUEL PRESSURE SWITCH
17	LOW FUEL PRESSURE SWITCH
18	FUME PRESSURE SWITCH
19	CONTROL PANEL

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EP Products, Inc.
Environmental Remediation Products & Services

THERMAL OXIDIZER
GENERAL ARRANGEMENT

STD NO:
PLOT SCALE NONE
AUTOCAD FILE NAME 4128-03A
PLOT DATE 11-15-95

DATE DRAWN	11/15/95
DRAWN BY	MARK KILL
APPROVED BY	
DRAWING NUMBER	B-03A
PROJECT NUMBER	2449-4128
FIGURE NUMBER	

EP Products, Inc.
Environmental Products & Services

THERMAL OXIDIZER
REQUEST FOR QUOTATION

Name/Title: _____

Company: _____ SIC Code: _____

Address: _____

City: _____ State: _____ Zip: _____

Phone: _____ Fax: _____ E Mail: _____

Site: ☐ Industrial ☐ Terminal ☐ Treatment Plant ☐ Remediation ☐ Other

Fume Volume: Minimum _____ Maximum _____

Fume Temperature: Minimum _____ Maximum _____

Oxygen Content: Minimum _____ % Maximum _____ %

Contaminant Composition:

Volatile Name	Influent Concentration Untreated Max.	Influent Concentration Untreated Min.	Destruction Rate Efficiency	CAS Number

Provide a brief description of the process: _____

Auxiliary Fuel/Electrial Requirements: ☐ LP ☐ Natural Gas ____Volts_____Phase, 60 Cycle

Control Panel Location: ☐ Mounted with oxidizer ☐ Remote mounted

NEMA Requirement: ☐ 4 ☐ Other _____

OPTIONS: ☐ Heat Exchanger Effectiveness _____ ☐ Catalyst ☐ Telemetry
☐ Trailer Mounted ☐ Auto Dialer

Regulatory Agency: ☐ Clean Air/Water Act ☐ State ☐ EPA ☐ Local

☐ Purchasing ☐ Renting ☐ Leasing

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ALZETA CORPORATION

June 24, 1998

Mr. Ed Bondarewicz
PARSONS ENGINEERING SCIENCE
1700 Broadway, Suite 900
Denver, Colorado 80290
Fax: (303)-831-8208

Subject: ALZETA *EDGE QR* Quick-Response Flameless Thermal Oxidizer
U.S. Army Chemicals Facilities Decon Waste Gas Stream Abatement

Dear Mr. Bondarewicz:

Thank you for your interest in Alzeta's flameless thermal oxidizer. The purpose of this letter is to assure you that we can provide you with a VOC Abatement system that more than meets your expectations for performance, reliability, and safety.

The *EDGE QR* flameless thermal oxidation system is designed to maximize destruction efficiencies and to minimize operating costs. Benefits that it will provide are:

- Patented "Pyrocore" incandescent burner for 99.99%+ destruction of the most difficult chemicals (EPA verified),
- Ultra-low NOx and CO (<10 ppm corrected to 3% O2) emissions (EPA verified),
- Effective prevention of dioxin and furan formation as products-of-incomplete-combustion and through "de novo" synthesis (EPA verified),
- Quick response (2 seconds to reach maximum temperature) low thermal mass allows the oxidizer to spontaneously and reliably respond to changes in process flow and VOC concentrations,
- Flashback and corrosion-resistant surface combustion allows for unparalleled safety and robust performance, and
- Higher operating temperatures require less dilution air, for highly concentrated streams, resulting in smaller oxidizer capacity requirements.

Alzeta also offers engineered and integrated systems, offering enhancements such as:

- Proprietary two stage heat exchanger and water quench chamber to effectively prevent system corrosion from acid gases,
- High performance packed tower scrubber for 99%+ acid gas and mist removal, and
- Rotary zeolite concentrators for dilute streams, reducing oxidizer throughput by factors of 10 and 20:1, with 99%+ reliability (uptime).

We are prepared to do everything necessary to assure that your project is a successful one. Some of the services that we can offer you, include:

- Installation, start-up and certification support,
- 24-hour service hot-line and extended services agreements,
- Regulatory support and interface, and
- Design services to accommodate your future process modifications.

We look forward to discussing your needs (including a lease with an option to buy) at your earliest convenience! Until then, please feel free to contact Jim Gotterba or me with any questions at (800)-676-8281.

Very truly yours,

Bruce C. Myatt, P.E.
National Sales Manager

2343 Calle Del Mundo
Santa Clara, CA 95054
Fax 408 ▲ 727 ▲ 9740
408 ▲ 727 ▲ 8282

Cost Effective VOC Abatement Technology

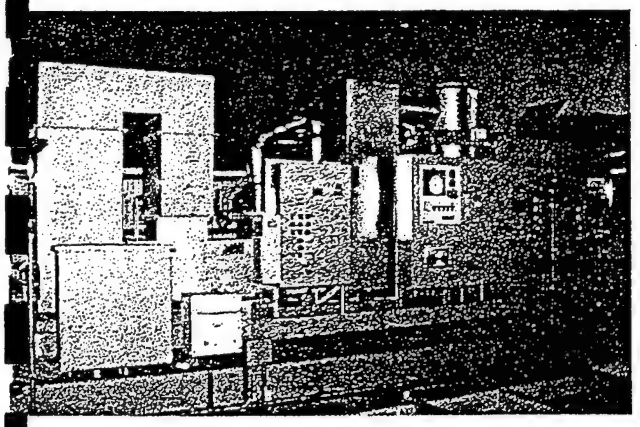
...Get the ALZETA

Effective Destruction of Gaseous Emissions

EDGE SB™

Advanced Flame Type Thermal Oxidizer using Alzeta's Pyromat SB semi-radiant burner.

- 99.9% VOC destruction with NOx and CO less than 10 ppm.
- Reduced fuel burn with optional energy saving recupeator.
- Solutions for chemicals creating solid oxides.

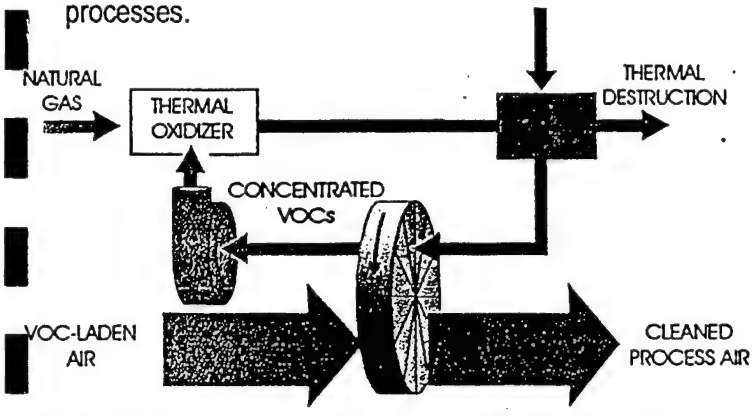


EDGE PLUS+ Concentrator with SB Oxidizer

EDGE PLUS+™

Concentrates VOC's to reduce thermal processor flow by a ratio of 10:1 to 40:1.

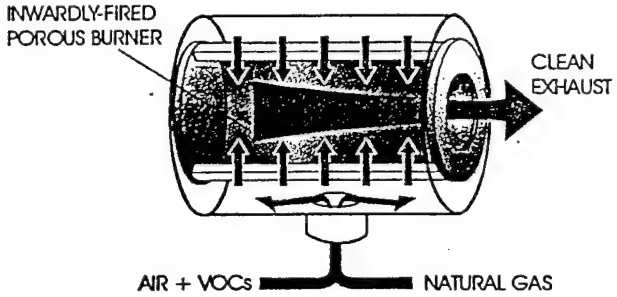
- Handles most VOC's including chlorinated compounds.
- Uses any of Alzeta's EDGE Thermal Processors.
- Most cost effective for dilute and continuous processes.



EDGE QR™

Ultimate VOC destruction with Alzeta's Pyrocore Incandescent Flameless Oxidizer.

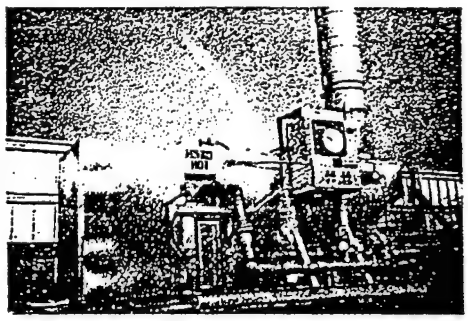
- 99.99% destruction with chlorinated chemicals.
- Quick response: < 2 seconds is ideal for intermittent processes.
- Essentially no NOx, CO, or incomplete combustion.



EDGE II™

Effective oxidation with Alzeta's Graded-Cell Catalyst.

- Maintain over 99% destruction efficiency over a wide range of inlet concentrations.
- Longer catalyst life.
- Lowest fuel burn 0.4% with energy saving recuperator.



EDGE II-R Recuperated Catalytic Oxidizer

ALZETA CORPORATION

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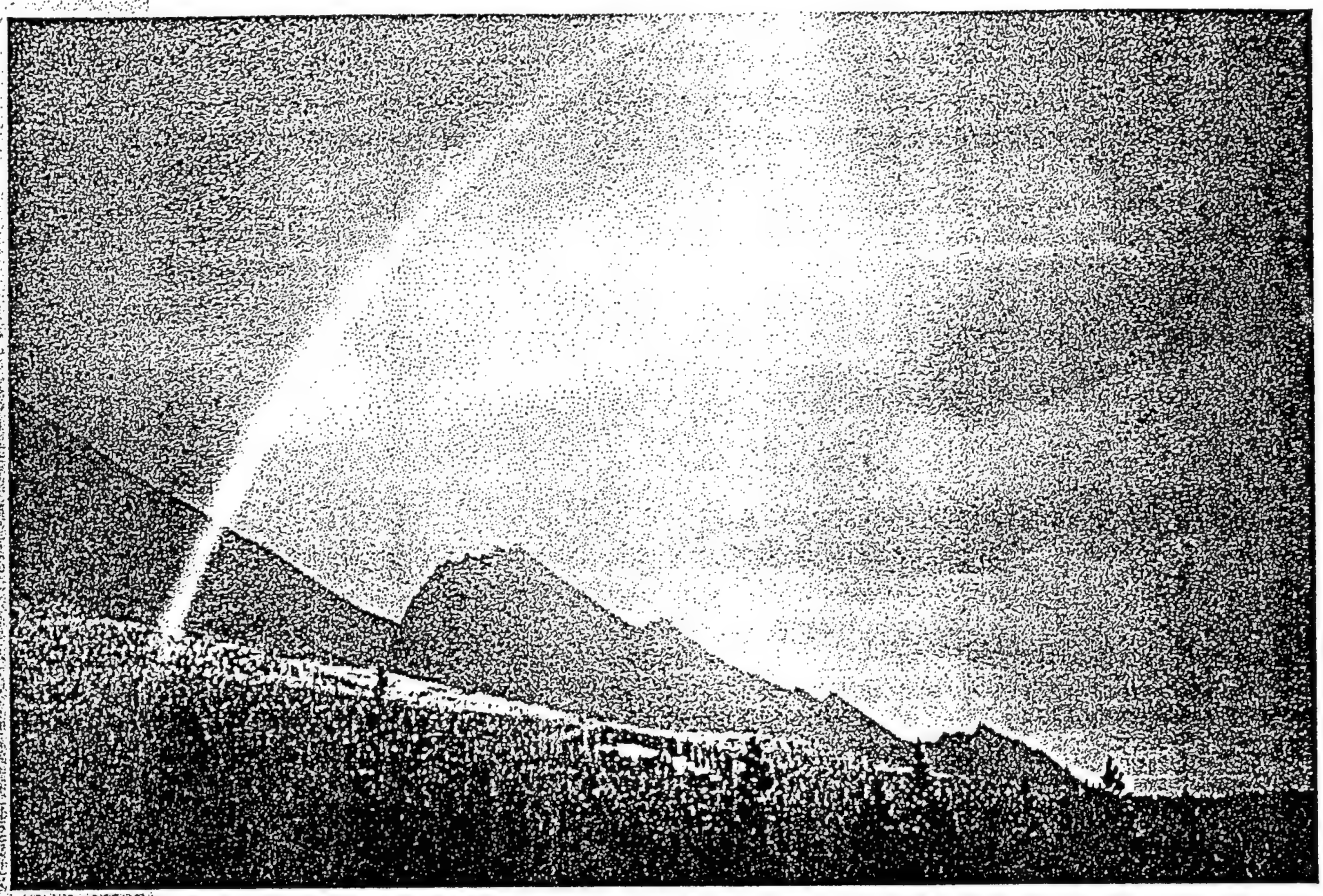
Phone (408)727-8282 - FAX (408)727-9740 - E-Mail alzeta@aol.com

EDGE QR

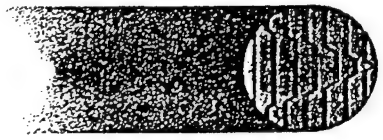


Clean and **Simple**
Flameless Thermal Oxidation
VOC Abatement Systems
with **ALZETA**'s Patented **Pyrocore**® Technology

for the Full Spectrum of Soil Vapor Extraction
and Groundwater Remediation Projects

ALZETA
CORPORATION

EDGE QR



Flameless Thermal Oxidation

The Heart of Alzeta's EDGE QR VOC Abatement Systems

The ***EDGE QR* Flameless Thermal Oxidizer** is based on Alzeta's Pyrocore premixed, surface combustion, radiant burner products. This patented device consists of a cylindrically shaped, low density, porous, metallo-ceramic shell approximately 1/2" thick attached to an external steel support structure. Surrounding this cylindrical shell is a larger steel sheath that forms the unit's outer casing and serves as an inlet supply duct for the VOC-laden air.

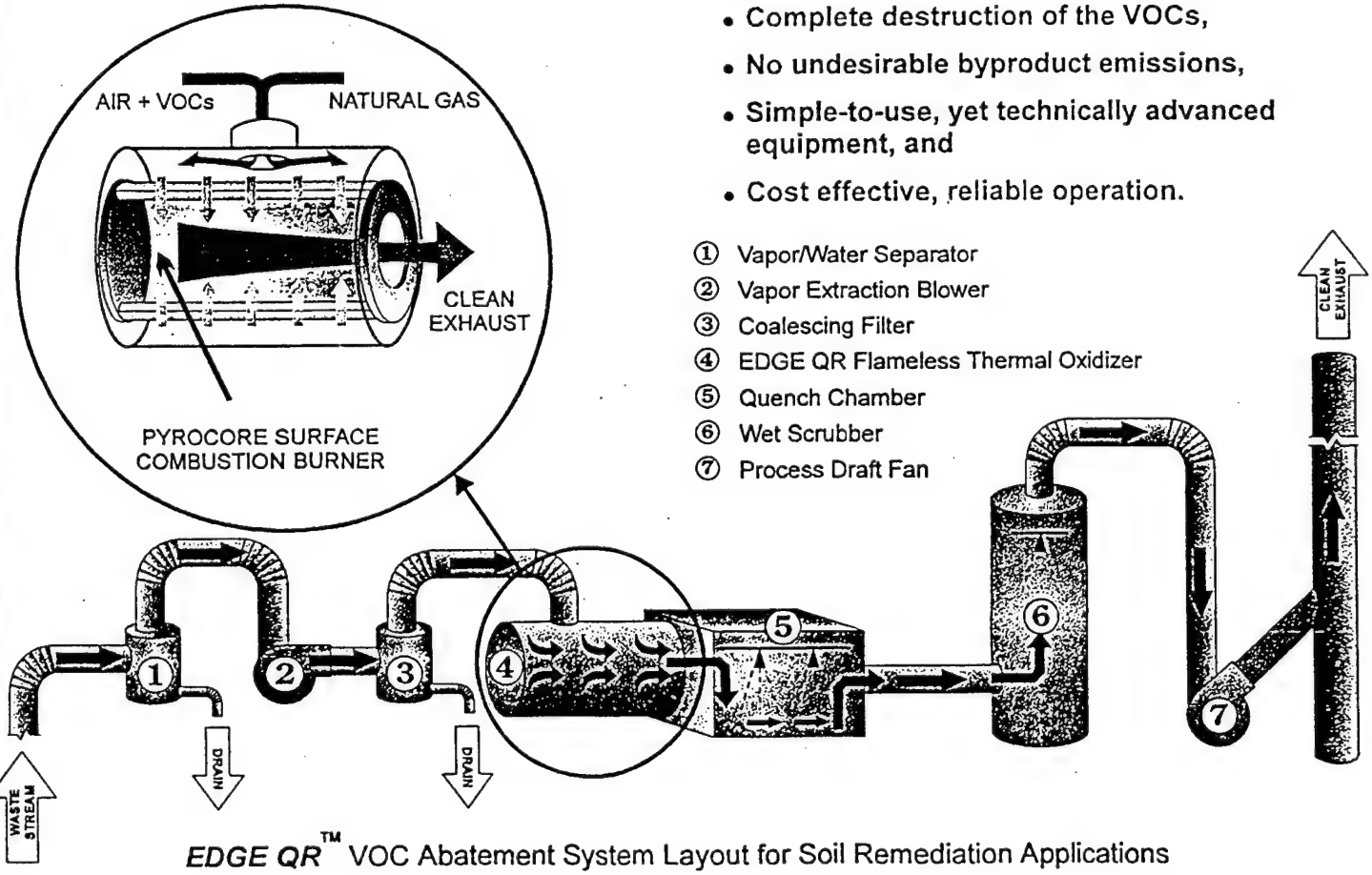
The VOC-laden air and supplemental natural gas are mixed upstream of the oxidizer and then flow uniformly through the porous ceramic layer from the outside inwards. Flameless Thermal Oxidation takes place on the inside surface of this cylinder. The distinctive appearance of the oxidizer is a uniform incandescent glow at approximately 1500°F to 1800°F without any visible flames and a uniform release of heat over its entire surface.

Key features of the ***EDGE QR* Flameless Thermal Oxidizer** assure the ultimate in performace for soil and groundwater remediation applications:

- **The VOCs, air and supplemental fuel are completely mixed,**
- **The VOCs are held in intimate contact with the high temperature oxidation zone,**
- **The heat of oxidation is radiantly recuperated within the porous ceramic lining, and**
- **No bulky refractory chambers or beds are used.**

These unique features reduce abatement costs and allow the user to remain competitive in the global economy, while complying with increasingly stringent air quality requirements:

- **Complete destruction of the VOCs,**
- **No undesirable byproduct emissions,**
- **Simple-to-use, yet technically advanced equipment, and**
- **Cost effective, reliable operation.**



EDGE QR™ VOC Abatement System Layout for Soil Remediation Applications

The Ultimate in VOC Destruction

Alzeta's *EDGE QR™* VOC Abatement System is proven technology which aggressively destroys VOCs with our patented **Pyrocore® Flameless Thermal Oxidation** technology.

- Chlorinated hydrocarbons such as trichloroethylene (TCE)
- Fluorinated hydrocarbons such as hexafluoroethane (C2F6)
- Chloro-fluoro-carbons such as dichlorodifluoroethane (Freon 12)

- ✓ **Ultra-High Destruction Efficiency - up to 99.9999% demonstrated**
- ✓ **Proven reliability and durability**
- ✓ **Destroys Halogenated and Non-halogenated VOCs including CFCs**
- ✓ **Negligible PICs, NO_x and CO**

Destruction Efficiency Performance

VOC Treated	Destruction Efficiency
Methylene Chloride	99.9922%
Chlorobenzene	99.9996%
Trichloroethylene (TCE)	99.9995%
Dichloroethylene (DCE)	99.9986%
Dichlordifluoroethane (Freon 12)	99.9999%
Hexafluoroethane (C_2F_6)	99.9999%

PICs and Criteria Pollutants

PIC/Criteria Pollutant	Discharge Concentration
Total TCDD	0.85 ng/dscm
Total TCDF (furans)	4.3 ng/dscm
NO_x	< 2.5 ppm
CO	< 1.5 ppm

Test Methodology:
VOST, EPA Method 0030 by EPA Control Technology Center and Acurex Environmental Corp.

EPA Tested and Confirmed

Under a coordinated development and testing program including the EPA's Control Technology Center, the Gas Research Institute (GRI), and California's South Coast Air Quality Management District (SCAQMD), Alzeta sought and achieved independent confirmation of the performance of our ***EDGE QR*** systems. Halogenated VOCs were conclusively destroyed without generating significant levels of PICs (dioxins and furans) or other Criteria Pollutants (NO_x, CO, and UHCs). With comparable performance demonstrated at operational facilities such as McClellan Air Force Base, Sacramento, California, these results are not mere expectations of future performance. These are results you can depend on - high DREs, low NO_x and CO emissions and negligible dioxins and furans.

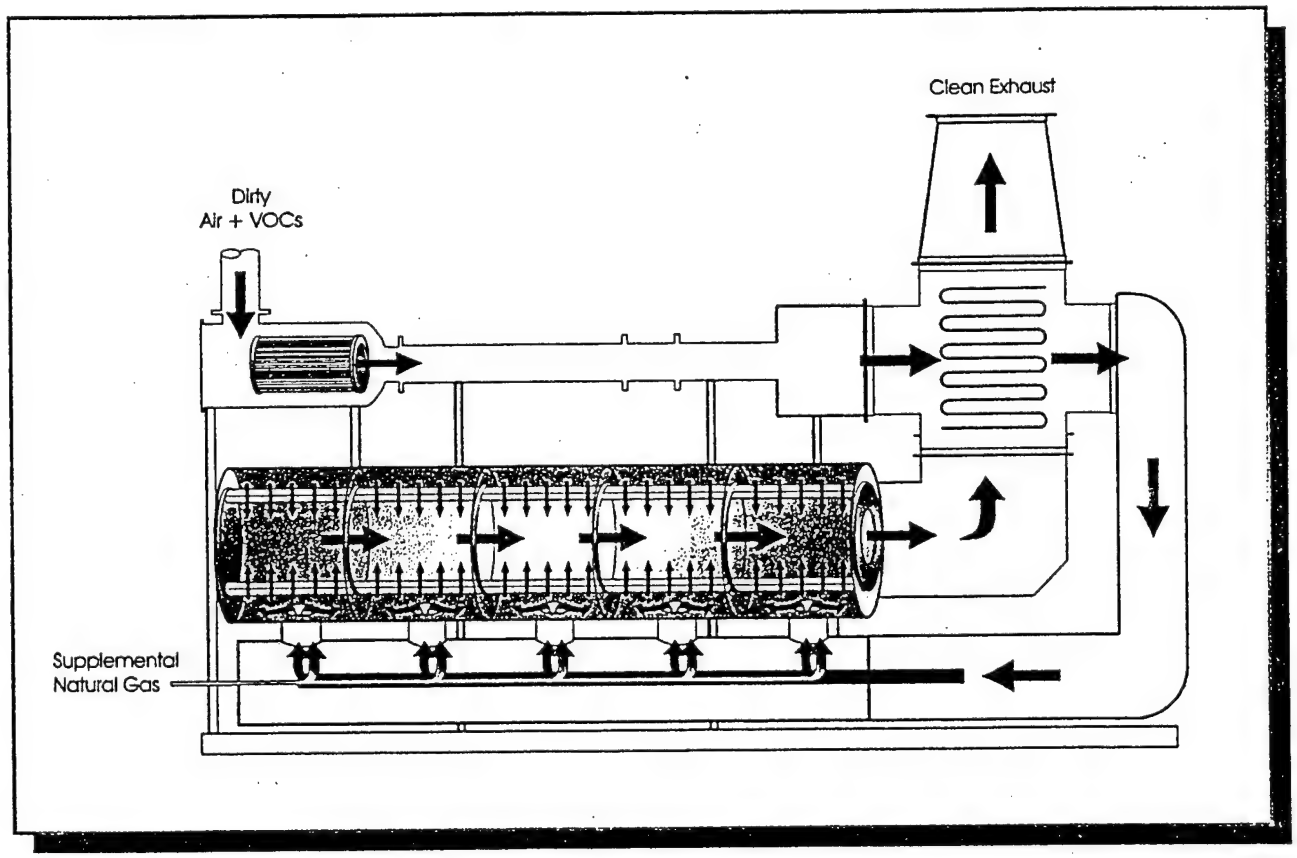
Reliability of Alzeta's ***EDGE QR SVE*** **Systems** is also field proven, with applications in a range of industrial facilities. In the semiconductor industry, where reliability and operational uptime availability is crucial to system acceptance, over 99% availability has been demonstrated. And, with many applications exposed to the rigors of halogenated VOC abatement and the generation of corrosive acid gases, Alzeta has proven its credibility as a source for long lasting, reliable, and ruggedly designed equipment.

Halogenated VOCs

Chemical Pollutants that are a threat to our soils, water and air

Since the Clean Air Act Amendments of 1990, increased attention has been given to the release of hazardous air pollutants (HAPs) associated with soil remediation and groundwater cleanup projects. In particulate, many of the organic solvents found in these projects contain halogenated VOCs. These are more difficult to control than non-halogenated materials and produce corrosive acid gases that often reduce system reliability. In addition, oxidation of these compounds, especially with catalytic oxidation systems, often generates products of incomplete combustion (PICs) such as dioxins and furans - materials that are considered more toxic than the original compounds being destroyed.

When halogenated compounds are encountered, Alzeta's ***EDGE QR* Flameless Thermal Oxidation Systems** eliminate these concerns and is an ideal choice for off-gas abatement. Alzeta offers complete, packaged systems specifically designed to achieve the highest Destruction Efficiencies for both halogenated and non-halogenated VOCs. These integrated systems come complete with vapor extraction and air/liquid separation hardware, the ***EDGE QR* Flameless Thermal Oxidizer**, and exhaust gas quench and acid gas neutralization systems as required.



2400 scfm ***EDGE QR-R*** Recuperated Flameless Thermal Oxidizer

ALZETA CORPORATION

...Get the **ALZETA** *EDGE*

(*E*ffective *D*estruction of *G*aseous *E*missions)

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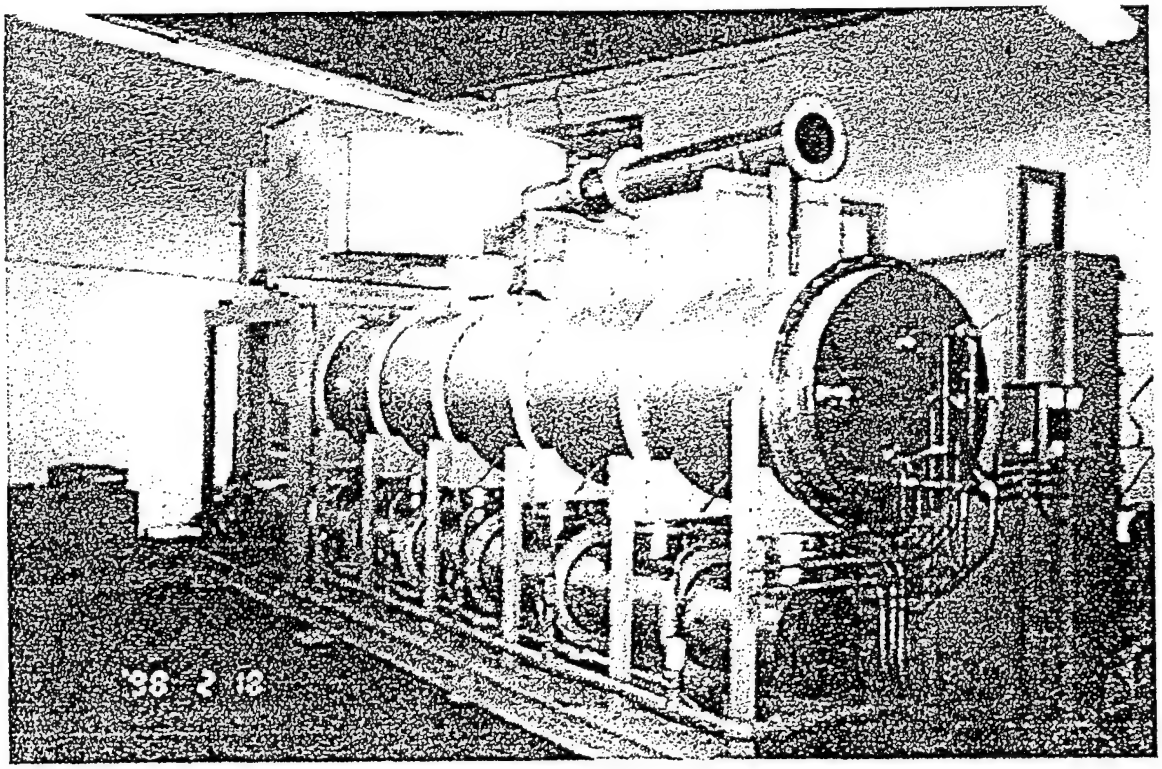
EDGE QR

...Get the ALZETA *E*ffective *D*estruction of *G*aseous *E*missions

Maximize Your VOC Destruction with

Flameless VOC Oxidation Technology



- VOC destruction efficiencies of over 99.99%
- Effective prevention of dioxin and furan formation
- Ultra-low NOx and CO emissions, below 5 ppm
- Compact and lightweight modular units
- Quick and robust response of < 2 seconds is ideal for intermittent or batch processes
- Corrosion resistant ceramic burners, water quench and scrubber
- Flashback resistant surface combustion for safe and reliable performance

ALZETA'S EDGE

VOC PERFORMANCE EVALUATION

The attached Applications Questionnaire is used to select and calculate the performance of Alzeta's products for control of volatile organic compounds from process air streams.

The information is required to provide a thorough evaluation of the VOC abatement application, selecting the most economical and efficient system for the application parameters. The end user or consulting engineer is then presented with sufficient data to evaluate the use of Alzeta technology based on system performance, operating cost and capital expenditure.

Our evaluation and recommendations require a certain amount of input data. We strongly recommend that the organic content of the stream be calculated based on supply of raw materials to the process in question, rather than instantaneous measurements of VOC in the exhaust stream. If the stream specification has to be based on actual measurements, these should at least be checked against purchase or use records.

Most of the entries on the form should be self-explanatory. Please note that acfm at temperature is requested. Scfm (cfm at 70°F) is perfectly acceptable, as long as the form is marked to show the units used.

If the relative humidity of the process stream is not known, please use the highest relative humidity of the original air supplied to the process, and note the temperature, so that this data can be converted.

Dust and contaminant loadings may not be known in exact quantities. If this is the case, please describe the process supplying the VOC stream, and give any available data from the operation.

If the VOC type in the stream is not shown on the preprinted form, please write in additional compounds, and/or cross out the preprinted solvents, and substitute the actual solvents used.

TABLE II
Destruction Efficiency Results from Evaluation Test Program

POHC or Condition	Average Run POHC Concentration (ppm_v)	Molecular Weight (g/mole)	Average Destruction Efficiency (%)	Minimum Detection (ng/liter)	DRE Detection Limit (%)
2-Butanone (MEK)	99	72	99.9998	0.5	99.999843
2-Butanone (MEK)	92	72	99.9988	0.5	99.999831
Methylene chloride (Dichloromethane)	97	85	99.9766	0.5	99.999864
O-Xylene	36	106	99.9880	0.5	99.999706
O-Xylene	61	106	99.9996	0.5	99.999827
Chlorobenzene	55	12.5	99.9982	0.5	99.998371
Chlorobenzene	88	112.5	99.9998	0.5	99.999887
Chlorobenzene	92	112.5	99.9996	0.5	99.999892
Trichloroethylene	117	131	99.9994	0.5	99.999927
Trichloroethylene	542	131	99.9994	0.5	99.999984
Dichloroethylene	59	97	99.9956	0.5	99.999804
Dichlorodifluoroethane**	100	102	99.9999	0.2	99.999956
Dichlorodifluoroethane**	1,000	102	99.9999	0.2	99.9999956
Hexafluoroethane***	100	138	99.9999	0.2	99.999967
Hexafluoroethane***	1,000	138	99.9999	0.2	99.9999967
Combustion blank	0	N/A	N/A	0.5	N/A

* Not corrected for combustion blanks.

** DRE D.L. (%) = $\{[POHC_{in(ppm)} - ((10ng/20L)*(1g/1EQng)*(1mol/MW_{(g)})*(22.42/mol)*1.0E6)_{(ppm)}]/POHC_{in(ppm)}\}*100$

*** DREs for these tests were calculated using a PQL of 0.2ng on the column (the lowest level seen in static bulb calibrations) for the 1L injections.

TABLE III
Criteria Pollutant Emissions

POHC	NO_x* (ppm_v)	CO* (ppm_v)	HCs** (ppm_v)	POHC	NO_x* (ppm_v)	CO* (ppm_v)	HCs** (ppm_v)
2-Butanone (MEK)	2.23	-1.71	-7.52	Trichloroethylene	1.14	0.02	-5.22
2-Butanone (MEK)	2.46	-0.12	-4.63	Trichloroethylene	1.55	-0.41	-0.82
Methylene chloride (Dichloromethane)	-0.12	0.61	-2.13	Dichloroethylene	1.66	-0.84	-6.94
O-Xylene	1.71	-0.59	-5.97	Dichlorodifluoroethane	2.03	-0.37	-1.27
O-Xylene	1.99	1.40	-1.37	Dichlorodifluoroethane	2.00	-1.87	0.14
Chlorobenzene	1.20	-0.37	-2.81	Hexafluoroethane	1.54	-1.99	-0.86
Chlorobenzene	1.70	0.26	-7.23	Hexafluoroethane	1.84	-0.01	2.80
Chlorobenzene	2.10	-1.37	-6.37	Combustion blank	2.48	0.15	-5.32

* As measured (wet at approximately 10% O_2), average of test condition.

** Measurements based on propane.

ALZETA CORPORATION

Addendum

Reader:

After Table II was printed for the publication of the International Conference on Incineration and Thermal Treatment Technologies proceedings, we received feedback from EPA refining the test results. The Table printed below was in fact used in John Sullivan's presentation on May 9, 1996 at the conference.

Note that the Average Destruction Efficiency for methylene chloride is 99.9922% rather than the 99.9766% that was printed in the conference proceedings.

Amended Average Destruction Efficiency Percentages from Table II.

POHC or Condition	Average Destruction Efficiency (%)
2-Butanone (MEK)	99.9996
Methylene chloride (Dichloromethane)	99.9922
O-Xylene	99.9965
Chlorobenzene	99.9996
Trichloroethylene	99.9995
Dichloroethylene	99.9986
Dichlorodifluoroethane	99.9999
Hexafluoroethane	99.9999

2343 Calle del Mundo, Santa Clara, California 95054
Telephone (408)727-8282 - FAX: (408)727-9740

ALZETA CORPORATION

EDGE
VOC CONTROL TECHNOLOGY
APPLICATION DATA QUESTIONNAIRE

To: Jim Gotterba
Alzeta Corporation
2343 Calle Del Mundo
Santa Clara, CA 95054-1008
Phone: 408-727-8282
Fax: 408-727-9740

Company: _____

Address: _____

City: _____

State: _____ Zip: _____

Contact Person: _____ Phone: _____

Application: _____ Extension: _____

Fax Number: _____

Item	
VOC Stream Data:	
Solvent laden air flow: (SLA)	acfm
Solvent load	lbs/hr
SLA temperature	deg. F
SLA Inlet pressure	inches water
Dust Load	lbs/hr
Required VOC removal	%
Relative humidity	% rh

Enter solvent name, percent of total, and molecular weight, if known.

Solvent Mixture	High %	Normal %	Low %	Molecular Wt.
Toluene				
Hexane				
Xylene				
Acetone				
MEK				
Isopropyl Alcohol				
Ethyl Acetate				
Other				
Other				
Other				

General data at the proposed plant location: _____

Plant location: _____

Ambient air temperature: deg. F

99% summer wet bulb temp: deg. F

Operating hours: hours/yr

Unit cost: natural gas $/mil Btu

2373 5053

APPENDIX C

COST ESTIMATE SUPPORTING INFORMATION

QUOTATION

NO. F1461-TK
REF.

HAUCK MANUFACTURING COMPANY P.O. Box 90, Lebanon, Pa. 17042

TO Parsons Engineering Ser. Inc.
1700 Broadway Ave., Suite 900
Denver, CO 80290

DATE September 16, 1998

Attention: Mr. Ed Bondavewicz

ITEM NO.	QUANTITY	DESCRIPTION	PRICE
		In response to your request for quote, I am pleased to submit the following: Single Zone/Single Burner Combustion System sized for approximately 1.5 mm Btu/Hr.	
		Burner Assembly	
1	1	Burner Unit, SVG130 rated for 1.5 mm Btu/Hr when supplied with air at 20 OSI P/N 53450	708.00
		Gas Line Components	
2	1	Nipple, FPN115B STSTL 1½" flex P/N 14345	58.41
3	1	Valve, LVG515 1½" limiting P/N 14966	70.80
4	1	Regulator, GI25N02-5 1" ratio P/N 50002	159.12
5	1	Flange Assy OMG115 1½" P/N 19807	82.60
6	1	Plate, orifice OMGx15 - 1397 P/N 19753X008	21.83
7	1	Valve, DA10-40-303A, 1½" Ball P/N 41610	62.54

By Tom Kimmel Tom Kimmel

Please refer to quotation number on all correspondence.
See reverse side for terms and conditions of sale.

QUOTATION

NO. F1461-TK
REF.

HAUCK MANUFACTURING COMPANY P.O. Box 90, Lebanon, Pa. 17042

TO Parsons Engineering Ser.,Inv.
Denver, CO

DATE September 16, 1998

Attn: Mr. Ed Bondavewicz

E NO.	QUANTITY	DESCRIPTION	PRICE
8	1	Manifold, PGM2107 auto gas P/N 43941	2,400.12
9	1	Regulator, S201H, 1½" P/N 802119X007	877.92
		Air Line Components	
10	1	Nipple, 3" Male/RPM Flg. x 13" Lg P/N 45008	169.92
11	1	Valve, BVA440BX w/B & L and M7284 P/N 44375R	846.06
12	1	Gauge, G33195 0-55 IWC P/N 13237	48.97
13	1	Switch, press C437H-1001 1-16 oz P/N 802088	138.06
14	1	Blower, TBA20-15-T-(*) *Discharge position must be stated at time of order. P/N 18591X	3,773.46

Tom Kimmel

By_____

ease refer to quotation number on all correspondence.
See reverse side for terms and conditions of sale.

QUOTATION

NO.
REF. F1461-TK

HAUCK MANUFACTURING COMPANY P.O. Box 90, Lebanon, Pa. 17042

TO
Parsons Engineering Ser.Inc.
Denver, CO

Attn: Ed Bondavewicz

DATE September 16, 1998

E NO.	QUANTITY	DESCRIPTION		PRICE
		Ignition Components		
15	1	Generator, Spark Q624A1014 P/N 40198		128.03
16	5'	Wire, ignition lead (1 pc.5") P/N 14405	1.80/ft.	9.00
17	2	Terminal, trans. Rajah P/N 54120	3.54 Net	7.08
		Control System		
18	1	Control Panel, flame safety w/temperature controller, high temp limit, all annunciation lamps, alarm horn, and switches.		5,859.63
			TOTAL SYSTEM COST	15,421.55
			TWO SYSTEM TOTAL	30,843.10

Terms: Net 30 w/approval.

FOB: Factory

Delivery: 6 weeks after receipt of approval drawings.

By Tom Kimmel

ease refer to quotation number on all correspondence.
See reverse side for terms and conditions of sale.

BGF Industries, Inc.

May 21, 1998

Mr. Ed Bondarewicz
Parsons Engineering Sciences Inc.
1700 Broadway, Suite 900
Denver, CO 80290

Dear Mr. Bondarewicz:

Enclosed are six packets of information for your presentation. I have also enclosed Price Sheet #837 for our 1" and 1/2" BGFMat insulation. There is also a spec sheet just on the BGFMat itself in each packet.

As I mentioned in my voicemail we did not have any more samples of Style 7721 with the 972B flame resistant finish in the office. I have requested a 2-yard sample be sent to your attention from our manufacturing plant.

Price for Style 7721/57.5"/972B is $9.93/ln. yd. Standard roll size is 100 yards. If you could use second quality material price would be $5.96 ln. yd. We have several rolls of seconds available. The major defects in these would be aesthetic in nature and would not compromise on performance.

Should you require any additional information please give me a call.

Best regards.

Elisabeth Cox

Elisabeth Cox
Cox ParsonsEngrSciences
PresentatnS-21-98 L-js

Enclosures

MEGTEC Systems
830 Prosper Road
P.O. Box 5030
De Pere, WI 54115-5030

920/336-5715

September 23, 1998

Mr. Ed Bondarewicz
Parsons Engineering Science
1700 Broadway, Suite 900
Denver, CO 80290
Fax: 303-831-8208

Reference: Request for Oxidizer Quotation, MEGTEC Systems File No. 110084 - Revised

Dear Mr. Bondarewicz,

Per your request, MEGTEC Systems is pleased to provide the following budgetary pricing and scope of supply for a VENTURA™ Thermal Oxidizer to meet your pollution control needs.

To eliminate hydrocarbons in a vapor stream with a destruction rate effectiveness up to 99% and NO_x emissions below 50 ppm, we recommend a VENTURA oxidizer with our exclusive ceramic Venturi-Jet high-efficiency burner. The venturi jet burner design can accept concentrations which range from 0% of LEL to over 100% of LEL. This arrangement uses the heating value of the fume stream as a fuel source. The oxidizer will also include our fume mixing chamber, auxiliary fuel supply piping, induced draft combustion air fan, and easy to operate process controls.

The VENTURA oxidizer provides destruction of Volatile Organic Compounds (VOC's) and odor control. It combines high temperature thermal oxidation with our unique VENTURA oxidizer to efficiently convert VOC's, and other odor causing organic compounds to carbon dioxide and water vapor.

Equipment Operation:

VOC-laden air enters the oxidizer through a burner supply plenum which injects the fume stream through multiple venturi throats at speeds greater than the flame propagation rate. Air is induced through the venturi array by the accelerated fume stream to provide sufficient oxygen for combustion. The mixture is combusted at the exit of the venturi and is combusted to flame temperatures of near 3,000 °F before being quenched to 1,800 °F at the exit of the ignition tube. The combusted mixture is then held at 1,800 °F for 2.0 seconds to ensure destruction of the VOC's.

The design is simple and effective and has been proven in operation for over 30 years. The MEGTEC Systems VENTURA oxidizer advantages include:

⇒ Uses the fume stream as the fuel source which lowers clean up time and fuel costs
⇒ Controlled by temperature not LEL, so there is not a need for a LEL analyzer which needs to be calibrated
⇒ Uses ceramic, venturi shape burner tile which eliminates the possibility of flashback and increases burner life
⇒ One year "no excuses" warranty included with purchase
⇒ Flame arrestor, strip chart recorder, skid, and exhaust stack are included in price.

One (1) VENTURA™ VBO-050 Thermal Oxidizer includes the following:

- One (1) Proprietary Venturi Jet High Efficiency Burner
- Fresh Air Damper
- Combustion (fresh air) fan w/volume control damper
- Unit Mounted Electrical Cabinet
- Exhaust
- Skid mounted unit

One (1) VENTURA™ VBO-050 Thermal Oxidizer includes the following (Cont.):

- Engineering drawings to assist customer in installation, start-up, and permitting of oxidizer
- One (1) year equipment warranty including parts, labor and expenses

Design Criteria

Process:	Remediation
Solvent loading:	up to 35 lbs/hr (100% LEL *)
Solvent Description:	JP4
Particulate:	None specified

* Solvent levels at peak conditions are assumed to be 100% LEL. The actual LEL must be quantified to ensure proper oxidizer sizing as the LEL levels above 50% directly affect the size of the combustion chamber.

Budgetary Pricing

Price of Ventura VBO-050 Thermal Oxidizer..... $ 69,908

Rental per month of Ventura VBO-050 Thermal Oxidizer ..... $ 6,990

This pricing is for budgetary purposes. A formal proposal will be supplied once the complete scope of the project is determined. The above budgetary price, does not include installation or start-up, and is ex-works DePere, Wisconsin.

This equipment can be manufactured and ready for shipment 16 weeks from receipt of purchase order. If this equipment is required in a shorter time period please contact MEGTEC Systems.

Standard Terms of Sale

30% with issuance of purchase order
30% 60 days prior to shipment
30% upon notification to ship (equipment cannot be released for shipment until payment is received)
10% 30 days after shipment

Rental Terms

- A security deposit equal to one (1) month rent is required before shipment
- First and Last months payments are due with purchase order
- A minimum of four (4) months rent is required
- Monthly payments are due the 1st of each month
- The system (if rented) must be returned in reasonable condition
- Any repairs necessary to the equipment will be billed on a time and material basis.
- 50% of the rental payments can be applied to the purchase of this system -- not to exceed 50% of the purchase price

Ed, thank you for the opportunity to provide this proposal. If you have any questions or comments, please contact Greg Gatenby or me at your convenience.

Sincerely,
MEGTEC SYSTEMS

Christine Roland

Christine Roland
Inside Sales Representative
Industrial Emission Control Products

clr:10084pa.doc

cc: Mohit Uberoi, Bill Verdonik, Greg Gatenby, Stephen Hirt - MEGTEC Systems

Enviro Reps, Inc.

2921 South Downing Street
Englewood, Colorado 80110

FACSIMILE COVER SHEET

PLEASE DELIVER THE FOLLOWING PAGE(S) TO:

Name: Raphael Katz
Firm: Parsons
Address:
City: State: Zip:
Facsimile Machine Number: 831-8208

Name: Gene Zumbrock
Date: 7/9/98
Facsimile Number: (303) 761-0380
Number of Pages: 1
(including cover page)

MESSAGE: Raphael

per your request, to purchase a standard thermal oxidizer in the 200 CFM size price will run approx. $36000.00. The purchase price on a 500 CFM THOX will run approx. $54,000.00

Rental prices for 4 months on 200 CFM THOX will run approx. $4800 & $5500 for the 500 CFM unit.

Please call with questions

For longer rentals, prices will come down per month.

Gene

If you do not receive all the pages indicated, please call (303) 761-5645 as soon as possible. Thank You

E PRODUCTS, INC. - THERMAL OXIDIZERS

1. Standard thermal oxidizer models:
   - 200 cfm, 1,400°F, 10' x 4' x 8', 2,600 lbs, 0.5 second residence time, and a 99.99% destruction efficiency.
   - 500 cfm, 1,400°F, 11' x 4' x 8', 3,100 lbs, 0.5 second residence time, and a 99.99% destruction efficiency.

2. Estimate on purchasing and leasing a standard thermal oxidizer:
   - 200 cfm: Purchase - $36,000 Lease - $4,800 (for 4 months)
   - 500 cfm: Purchase - $54,000 Lease - $5,500 (for 4 months)

   *All costs include a 10% contingency factor. Longer rentals will be based per month.

3. Custom-built thermal oxidizer models can be manufactured. An operating temperature of 1,800-2,100°F, residence time of 2 seconds and a 99.99% destruction efficiency can be obtained. Fuel usually used is natural gas or propane.

4. An estimate on the dimensions and weight of a custom-built thermal oxidizer 200 cfm model are as follows:
   - 3' to 5' chamber diameter and a 24' chamber length.
   - 4,000 to 4,500 lbs.

   *A 500 cfm model will have a little greater dimensions and weight.

5. The cost of a custom-built model will be approximately double the cost of the standard models. Leasing is unavailable for custom-built models.

6. All design requirements are required in detail at time of purchasing or leasing. A "Request for Quotation" form must be completed prior to purchasing or leasing equipment (attachment). Delivery is usually within 12-18 weeks.

Gene Zumberge, Local Representative, Enviro Reps, Inc., Phone Conversation, 7/20/98.
Stephen Hirt, Director of Operations, E Products, Inc., Phone Conversation, 7/21/98.